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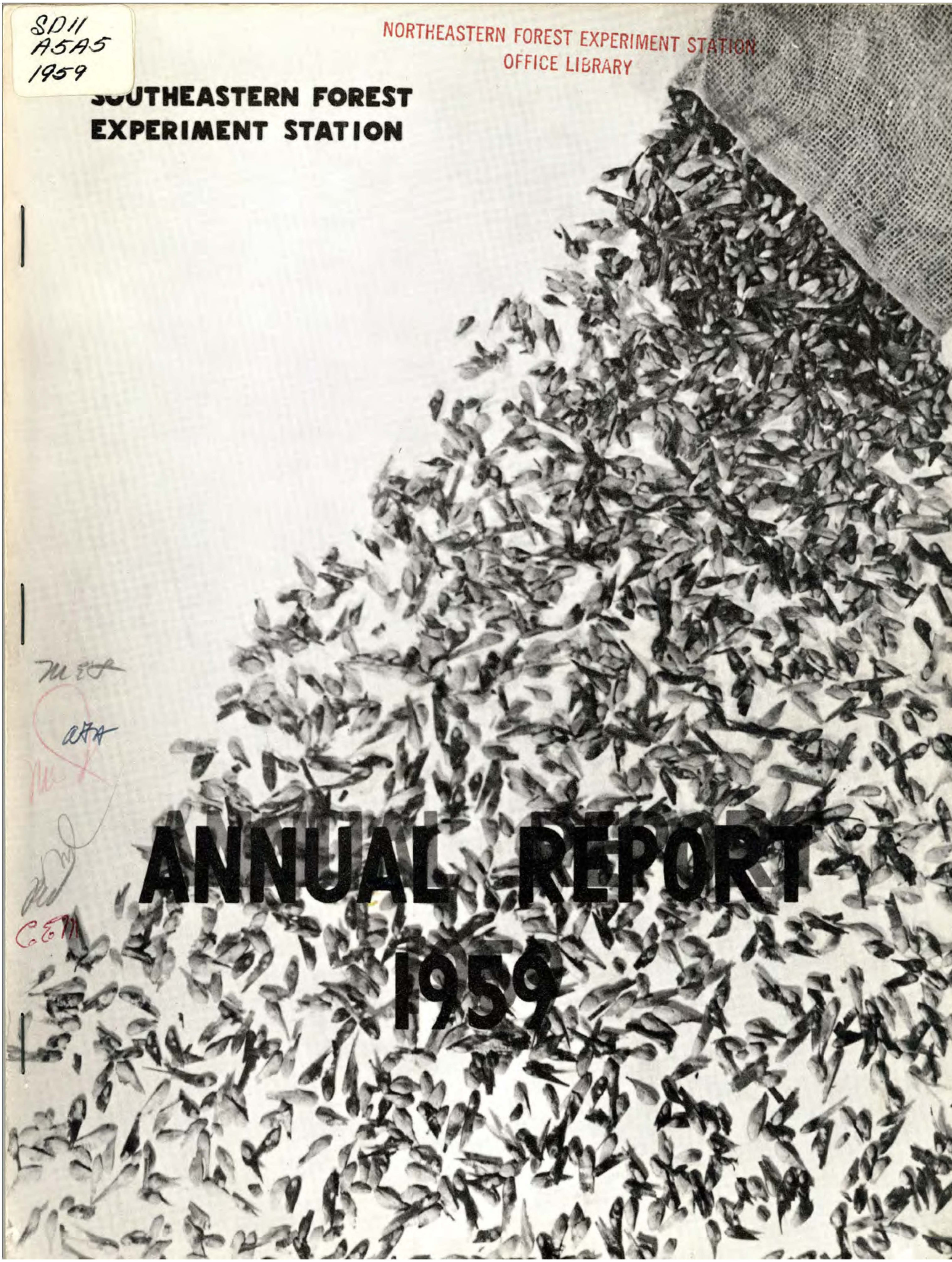

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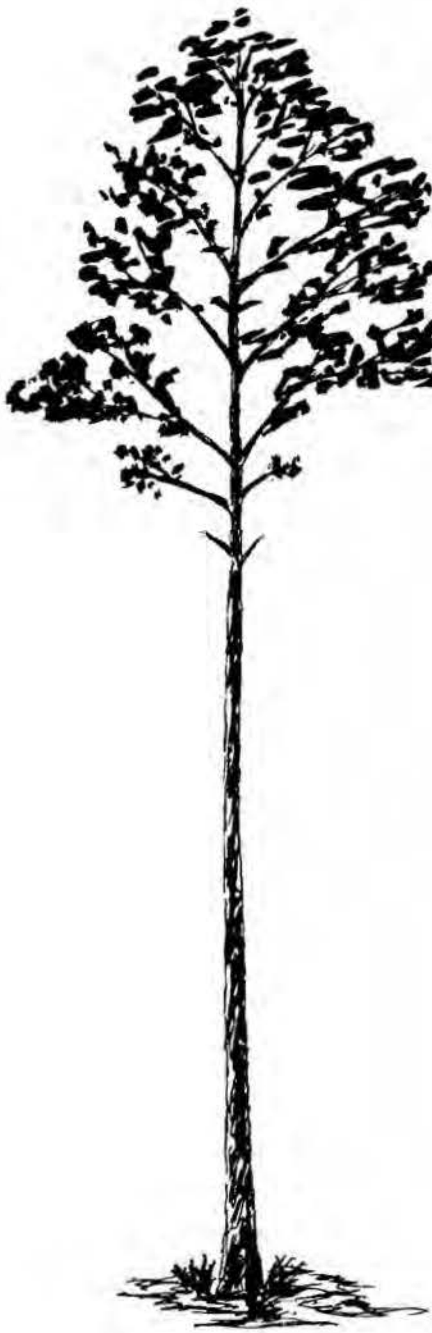


U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Southeastern Forest Experiment Station
Asheville, North Carolina

Joseph. F. Pechanec,
Director

CONTENTS

1959 Annual Report of the Southeastern Forest Experiment Station

FOREST MANAGEMENT

Intensification of forest management practices, expansion in forest tree nursery production, and increasing use of direct seeding within the Station's territory have created an interest and demand for research about forest tree seed. This interest involves greater knowledge of natural seed production, ways of producing more and better seed from superior parent trees, improved methods of handling, treating, and testing seed, and new and dependable means of obtaining adequate natural or artificial regeneration.

During 1959 we completed physical facilities, started programs, and finished a number of studies related to forest tree seed. Because of the interest and because many of our publications dealt with the subject, we have elected to emphasize "forest tree seed" as the major theme for this section of the annual report.

Work with forest tree seed embraces activities from basic physiology through applied research to pilot-plant tests and development. Such a span of activity means that publications provide only a partial measure of the results. An effort has been made in this report, therefore, to include work with forest tree seed which, although not always of a nature that warrants individual research publications, has helped materially to raise the level of forestry and forest production in the southeastern United States.

NATURAL SEED PRODUCTION

Knowledge of seed production in managed forest stands is essential before natural regeneration can be obtained consistently. During 1959, we reached some conclusions relating to loblolly pine seed production in the Virginia-North Carolina Coastal Plain, and shortleaf pine and oak seedfall in the Piedmont.

Loblolly Pine in the Virginia-North Carolina Coastal Plain

Twelve years of trapping loblolly pine seed in this area showed that seed crop size fluctuated from year to year in both uncut (fig. 1) and partially cut stands.

Stimulation of the seed source by preharvest release improved seed production, particularly in poor seed years. Stimulated, selectively cut stands of mature trees produced more seed than uncut stands of a similar age. Stimulated strips of seed trees and four or eight uniformly spaced seed trees per acre produced quantities similar to uncut stands.

Not only did stimulation improve seed production, but it also produced an increase in the percentage of sound seed (fig. 2).

Stand age is an important factor affecting seed production. Young forest-grown trees are generally unsatisfactory seed producers, unless stimulated by thinning or other preharvest release.

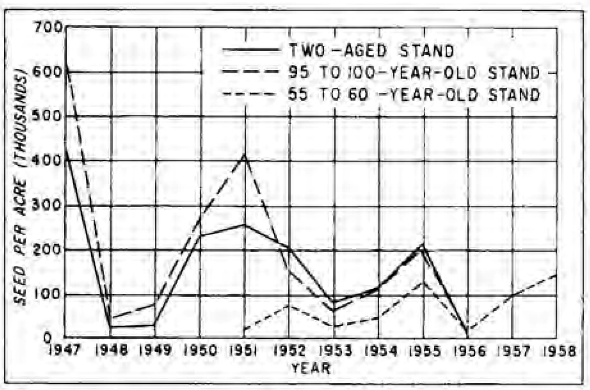


Figure 1.—Sound seed production in uncut mature loblolly pine stands in the Virginia Coastal Plain. A production level of 50,000 or more sound seed per acre occurred in 4 out of 8 years in a 55- to 60-year-old stand, 8 out of 10 years in a 95- to 100-year-old stand, and in 7 out of 10 years in a two-aged stand composed of 60- to 80- and over 100-year-old forest grown trees.

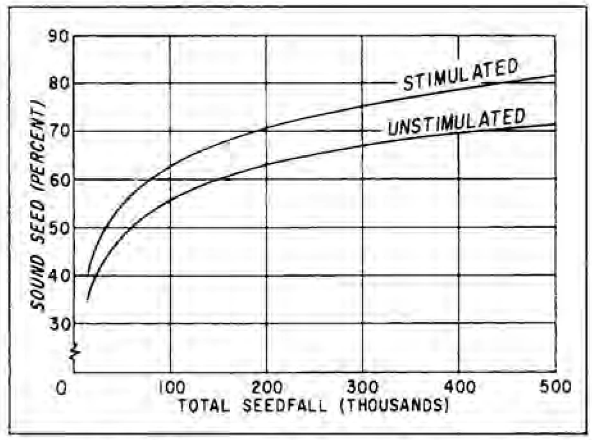


Figure 2.—Relationship of soundness with loblolly pine seed crop size and effect of stimulation. These data show that the relationship between seed crop size and percentage of sound seed is logarithmic instead of linear, as previous work had indicated.

Shortleaf Pine in the Piedmont

Additional evidence is accumulating which indicates that shortleaf pine is an erratic seed producer. Observations show that in five years a seed crop of 50,000 seed per acre or more has occurred only once at Union, South Carolina, twice at Morganton, North Carolina, and Clemson, South Carolina, and three times at Athens, Georgia.

Reliable estimates of cone crop would allow for adjustment of cutting plan to take advantage of good cone and seed crops and for effective seed collection plans. An estimating method has been developed for the Virginia Piedmont by the Charlottesville Branch.

This estimate is based on the ratio of conelets to cones in portions of the top of felled dominant or codominant trees. The number of conelets in the crop a year hence is then reduced by 55 percent and expressed as a multiple of the current crop.

Regeneration of natural shortleaf pine stands in the Virginia Piedmont has been recognized as one of the most important forest management problems in that region. All too often the failure to get adequate natural regeneration can be traced to either a lack of seed or its inability to germinate. Consequently, increased emphasis on shortleaf pine seed production and seedbed requirements has been incorporated into our research program.

Oak Seedfall in the Piedmont

Knowledge of acorn production is still principally in the sampling and trapping techniques stage (fig. 3). However, oak seedfall studies in the North Carolina Piedmont indicate that the 1959-60 acorn crop is the largest in 3 years. Almost three times as many acorns were trapped through early November 1959 as were collected during the entire collection period of the previous year. Scarlet oak outproduced white oak and black oak, and yielded a larger proportion of sound acorns (32 percent) than either white or black oak. A few individual trees of each species continue to stand out as excellent producers, although we have not been able to accurately tie down the factors associated with high production.

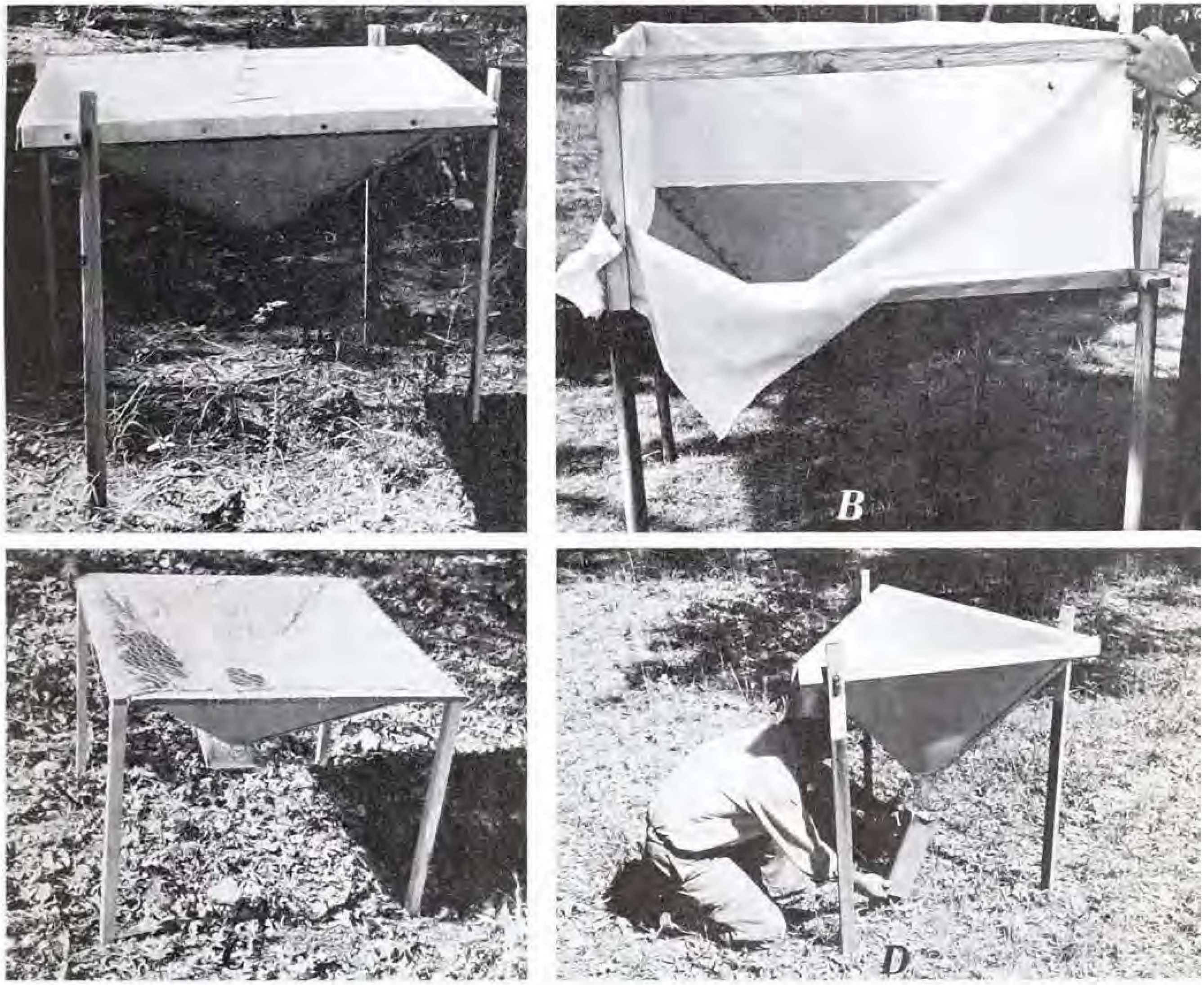


Figure 3.—Satisfactory seed traps for light-seeded pines and hardwoods have been available for a number of years, and the paper trap shown in *A* was described by Charleston Research Center personnel as early as 1951.

Sampling heavy-seeded oak and hickory has presented problems in trap design. One of the problems is the tendency for a high proportion of acorns and nuts to bounce out of standard traps. Three ideas have been developed by research personnel for restricting this bias. At Athens, Georgia, a buffer was constructed around the top of the trap (*B*). At Statesville, North Carolina, a burlap layer was strung across the mouth of the trap to reduce resilience (*C*). The triangular trap shown in *D* is an adaptation of the trap shown in *A*. The steeper angles deflect the seed to the bottom of the trap and practically eliminate loss from rebound.

Figure 4.—General view of part of a 5-acre slash pine seed orchard recently established at Lake City, Florida. This orchard contains 9 clones of the F_1 progeny of high gum-yielding trees. Irrigation is provided by pumping water into ditches between the rows.

PRODUCING MORE AND BETTER SEED

Seed From Superior Trees

In the Southeast, recent emphasis in forest tree improvement has been placed on wood quality, particularly with the southern pines. Immediate objectives of this work have been to distinguish the effect of environmental factors; to determine what and how much variation exists within trees, between trees, and between races; and to develop techniques for estimating wood quality. The Station's contribution to this field might best be illustrated with some examples of work now under way or completed in 1959.

In cooperation with the Forest Utilization Research Division, wood quality tests are being made on both the selected clones used in the Georgia Forestry Commission seed orchards and on the high gum-yielding strains developed at Lake City. Also, loblolly pine seed-source study material at the Lee Experimental Forest in Buckingham County, Virginia, will undergo specific gravity tests. The Forest Products Laboratory is analyzing samples taken by the Forest Survey throughout Florida and Georgia from all natural softwood pine species except cypress to determine the variation in wood specific gravity.

Wood quality characteristics, so important to pulp, paper, and other wood products, vary widely within species, and it is possible to select strains with certain desirable characteristics. Such things as tracheid length, cell wall thickness, specific gravity, fibril angle, and cellulose content affect pulp yield and strength qualities. A summary of studies in variation and inheritance of wood quality factors in southern pines has been prepared by Dorman (see bibliography). It indicates that the field of wood quality should receive greater emphasis when breeding for high gum yield, good form, and resistance to insects and disease.

A major development during the past year has been the attempt to combine high gum yield with other desirable traits in slash pine, especially rapid growth rate and high specific gravity. Gum yield is heritable to a rather high degree (heritability about 45 to 62 percent) and seed orchards are now being established to make use of the findings (fig. 4).

Combining high gum yield with other traits can be done in several ways. One way is to select for growth rate and specific gravity among progenies of high gum-yielding parents. In this case, growth rates and specific gravity of 14-year-old progenies have already been measured and heritability estimates of these traits are being made. A fair amount of variation is present, and the next step will be to make the selection and estimate possible gains. The trees having the highest degree of superiority in all three traits will be used as clonal stock for seed orchards if estimated gains warrant it.

Another method of combining traits is to cross trees selected for superiority in individual traits. Pollen is being collected from trees selected for superiority in gum yield, high specific gravity, and rapid growth, and will be mixed and applied to female flowers of each selection. These crosses will provide a progeny test of each selection, but some first-generation individuals superior in all three traits should result from the multiple matings. Such superior individuals will be used in clonal seed orchards and for further breeding.

Finally, one other approach is to establish a special type of seed-production area. A preliminary selection is first made in a young plantation on the basis of growth rate, specific gravity, and gum yield, and all undesirable trees are removed. The selected trees serve as an immediate source of seed for a modest gain. However, further work could also include eventual progeny testing of the selected trees with wind-pollinated seed. These tests will be the basis for further selection and thinning or for establishment of clonal orchards to produce seed for trees with high growth rates, specific gravities, and gum yields.

Seed Source Studies

Slash pine.—Slash pine seed-source studies in Georgia and Florida suggest that seasonal distribution of rain and length of growing season are instrumental in causing natural selection for variation found in growth rates. That portion of the species range where the climate is optimum appears to produce trees with higher growth rates, even when these trees are planted in other portions of the natural slash pine range.

A heterogeneous population of trees in this optimum climatic zone probably selects for superior growth rate among the trees themselves. The more rapidly growing trees will, on the average, dominate in greater numbers and produce the next crop, eventually resulting in trees which are inherently superior in growth rate.

On the other hand, trees at points progressively further away from this optimum climatic zone will favor other traits, probably those associated with survival. For example, in progressing northward, colder winters may cause more rigid selection for resistance to frost, with less stringent selection for rapid growth. The same could be true for rainfall at critical periods.

Thus, these tests suggest clinal variation deviating from what may be the "heart" of the species range. They also suggest that use of local seed may not always be the best policy and that seed collected from an apparently optimum zone may be made moderately superior even when planted in other climates with no great loss in survival. These early results may change as the test trees grow older, but if they hold, we may be able to deviate somewhat from the usual "local seed rule" to obtain a modest genetic improvement in slash pine by wise choice of seed sources.

Loblolly pine.—Among the plantings from 166 southern pine seed-sources in several studies at the George Walton Experimental Forest near Cordele, Georgia, are nine loblolly pine sources from seven states (table 1). Fifth-year results show that height growth decreases with decreasing average annual temperature. Incidence of southern fusiform rust did not vary with seed source. Also, there was little correlation between rate of height growth and incidence of fusiform rust, a relationship often suggested. No evidence of differences in susceptibility to Nantucket pine tip moth or pine webworm were evident.

Analysis of studies of racial variation at an early age may lead to erroneous conclusions if growth patterns change before the trees reach merchantable size. Height of stock from the three southernmost latitudes showed the same relative superiority in height over stock from the northernmost latitude after 5 years in the field as it did at 1 and 3 years.

Longleaf pine.—Fifth-year results of longleaf pine seed-source studies at Cordele have shown significant differences in height growth among sources. For example, a coastal plain source in Alabama (Baldwin County) averaged 2.2 feet taller than a piedmont Alabama source (Cleburne County). Stock from two sources in Louisiana had significantly less height growth than Georgia stock, but east

Texas stock did not. Survival was not affected by location of the seed source (table 2).

Table 3 summarizes the principal results of the Nansemond County, Virginia, installation of a north-south longleaf pine seed-source study after 6 years in plantation. Highly significant differences in survival and height growth are apparent between the most southern source and those farther north.

Seedlings from the Hillsborough County, Florida, source were damaged by severe frosts November 30 through December 3, 1958, when a series of freezing temperatures dropped to as low as 15° F. Figure 5 shows the resultant top kill. The tallest trees were damaged most severely. Some died; others put out new shoots which are still healthy.

The difference in height growth of the Florida source seedlings reflects frost damage, a general lack in vigor, and delay in coming out of the grass stage.

Yellow-poplar. — Yellow-poplar seedlings from sixteen geographic sources were planted in 1954 in a seed-source study on the Bent Creek Experimental Forest near Asheville, N. C. The sources ranged from southern New York and southern Michigan to northern Georgia and northern Mississippi.

Table 1.—Average seedling height and fifth year survival by temperature zone and latitude of seed source.

Seed source	Temperature zone	Latitude	Height			Survival
			1 year	3 years	5 years	
	Degrees F.	Degrees N.	- - - -	Feet	- - - -	Percent
Livingston Parish, Louisiana	67	30.4	0.76	3.3	9.3	79
Crisp and Wilcox Counties, Georgia	67	31.7	1.01	3.7	9.3	80
Onslow County, North Carolina	62	34.7	.84	3.3	9.0	74
Pamlico County, North Carolina	62	35.0	.85	3.4	8.7	84
Angeline County, Texas	67	31.1	.83	3.3	8.7	85
Cullman County, Alabama	62	34.1	.90	3.5	8.1	86
Jefferson County, Alabama	62	33.6	.83	3.1	7.8	85
Clark County, Arkansas	62	33.6	.91	3.1	7.8	92
Somerset County, Maryland	57	38.1	.74	2.9	7.8	87

Table 2.—Average height and survival after five growing seasons in longleaf pine seed source study at Cordele, Georgia.

Source	Average height	Source	Survival
	Feet		Percent
Baldwin County, Alabama	9.0	Baldwin County, Alabama	88.8
Treutlen County, Georgia	8.7	Cleburne County, Alabama	84.7
Polk, Tyler, and Hardin Counties, Texas	8.0	Rapides Parish, Louisiana	84.2
Washington Parish, Louisiana	7.7	Polk, Tyler, and Hardin Counties, Texas	82.6
Cleburne County, Alabama	6.8	Washington Parish, Louisiana	81.1
Rapides Parish, Louisiana	6.2	Treutlen County, Georgia	74.0

Although early height growth was confounded by deer browsing, growth initiation at the Bent Creek location still has retained the characteristics of the seed-source origin. The shorter the growing season at the seed-source origin, the later growth began in these tests (fig. 6).

In addition, morphological differences were apparent among the seed sources. Leaf shapes from a seed source near the eastern extremity of the range differed in lobe shape and depth of sinuses from those seed sources near the northwestern extremity (fig. 7). The pattern of these differences is being studied within seed sources to correlate physiological differences with noticeable morphological differences.

Table 3.—Six-year survival and height growth of longleaf pine in seed-source study in Nansemond County, Virginia

Seed source	Survival	Average height
	Percent	Feet
Rapides Parish, Louisiana	93.3	7.42
Harrison County, Mississippi	96.1	7.38
Treutlen County, Georgia	95.0	7.76
Nansemond County, Virginia	92.6	7.76
Hillsborough County, Florida	67.2	2.51

Figure 5.—Longleaf pine seedlings from Hillsborough County, Florida, in Nansemond County, Virginia, planting. These seedlings had less height growth and survival than more northern sources. They were frost damaged and showed a general lack of vigor.

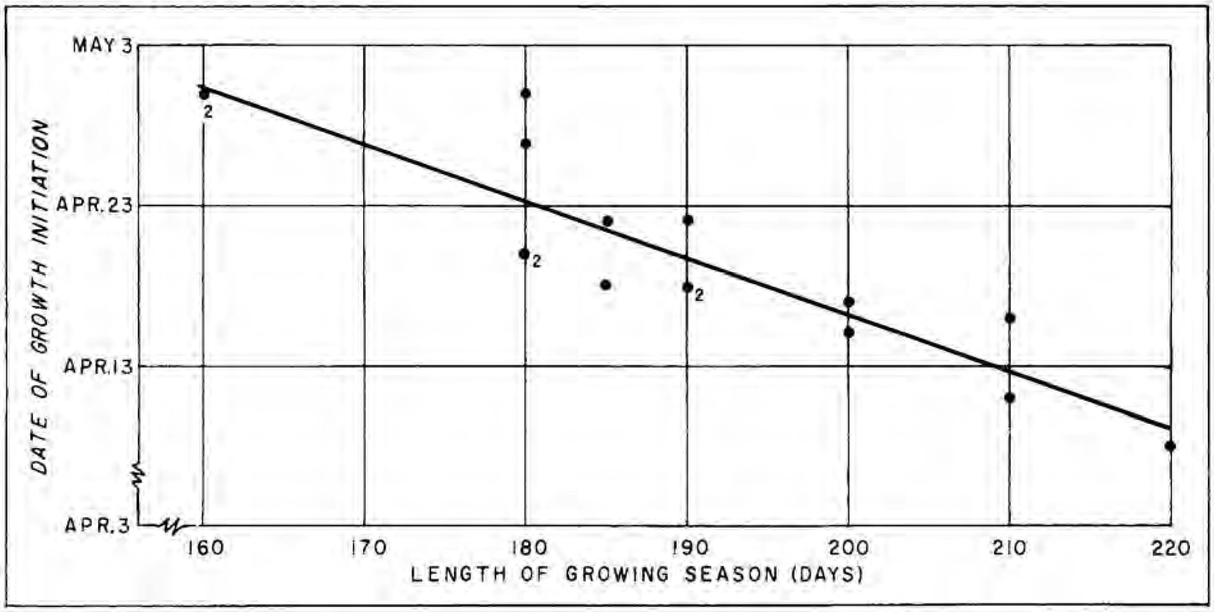


Figure 6.—Relationship of growth initiation to length of growing season at their origin for 16 different seed sources of yellow-poplar at Bent Creek Experimental Forest.

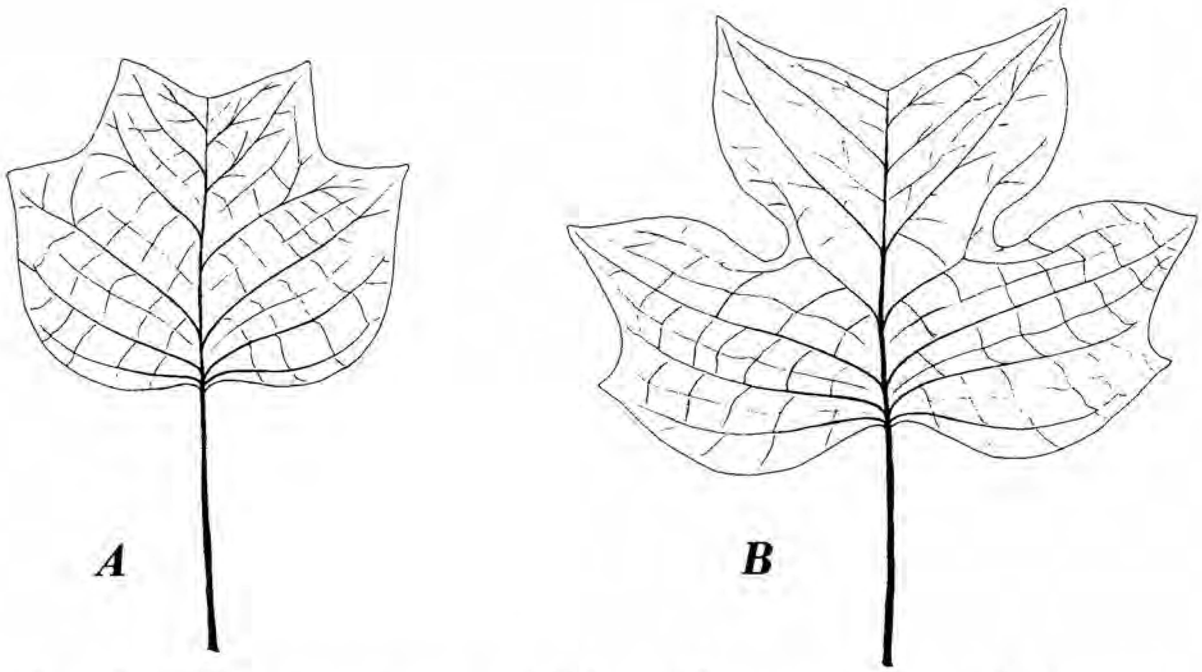


Figure 7.—Yellow-poplar seed-source study indicates differences in morphological characteristics among the seed sources. Note the difference in lobe shape and depth of sinuses between seed source from Wake County, North Carolina, (*A*) near the eastern extremity of the species range and Dexter, Indiana, (*B*) near the northwestern extremity of the range.

Physiology of Flowering

Studies of the physiology and biochemistry of tree flowering and seed production are being conducted in cooperation with Duke University. The exploratory approach to date has been to analyze parts of trees (especially buds, flowers, and conelets) to find the compounds or processes related to flowering and to discover pertinent differences in composition or processes between trees of different flowering potential.

Much of the past year was spent in developing satisfactory techniques for analyses of slash and loblolly pines. Methods for separating out terpenes and other resinous compounds, which occur in abundance in pines and which cloud identification of other organic compounds, have been developed. Specialized analytical techniques used in separation and identification of biochemical compounds are shown in figure 8, and radio-tracer techniques used to study processes in pine tissues are shown in figures 9, 10, and 11.

Seed Certification

In 1958, certification standards for forest tree seeds were accepted by the Georgia Crop Improvement Association. Since then, the time-consuming tasks of training inspectors, selecting trees in seed-production areas, establishing seed orchards, and setting up progeny tests (figures 12 and 13) have been under way. It will be possible, beginning in the fall of 1960, for a Georgia producer to market seed bearing the blue tag "Certified Seed" of the Georgia Crop Improvement Association.

During 1959, South Carolina, drawing upon Georgia's experience, enacted and put in operation legislation for certifying forest tree seed.

FROM EXTRACTION TO PLANTING

Seed Research

The new Seed Testing Laboratory at Macon, Georgia, sponsored by the Georgia Forestry Commission, the Georgia Forestry Research Council, the Southern Region of the U. S. Forest Service, and the Southeastern Forest Experiment Station, does service testing of seed besides seed research (fig. 14). Three phases of seed research during the past year yielded recommendations for cone and seed handling.

The deterioration of seed in air storage while waiting extraction and cleaning varies with species. Data obtained during the past year confirmed previous indications that longleaf pine is sensitive to prolonged air storage (fig. 15). Loss in viability is greater with longleaf than with slash pine. In the operation of cone extractories, it is suggested that longleaf be extracted as soon as the cones are opened.

Each year more forest tree seed is treated with bird and rodent repellents in direct seeding and in nursery plantings. Common latex stickers used in repellent treatments adversely affect seed germination; water uptake by the seed is restricted. To overcome this germination delay, the following steps have been found effective:

1. Test the seed before and after stratification but prior to application of the sticker and repellent chemical.
2. If stratification depresses either the rate or the total germination, use unstratified seed with the repellent treatment. The germination rate will be slowed, although the total germination will usually not be affected.
3. If stratification does not depress germination, the seed should be stratified prior to application of the sticker and repellent chemical. Stratification prior to application of the sticker will result in fully imbibed seeds and make it possible for germination to begin. The delaying action of the sticker will be minimized.

Seed Physiology Research

In addition to building seed-testing research facilities at Macon, Georgia, a seed physiology project has been housed and partially equipped during the past year and the program of the project has been developed. In addition to studies of damage during seed extraction and handling (fig. 16) and carbon nitrogen metabolism in pine embryo in isolated cultures, the following fields have been included in the project's scope:

1. Changes in the amino acid and sugar contents of pine seed during storage, stratification, and germination.
2. Changes in the nucleic acid and protein

contents of pine seed during germination.

3. Phosphorus and sulphur metabolism in germinating pine seed.
4. The activity of mitrochondria during germination.

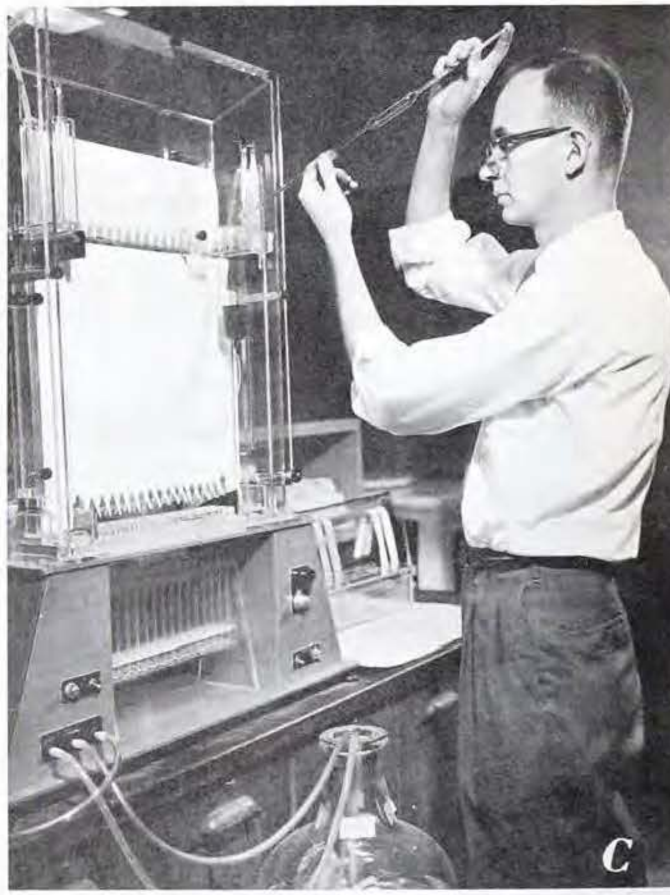
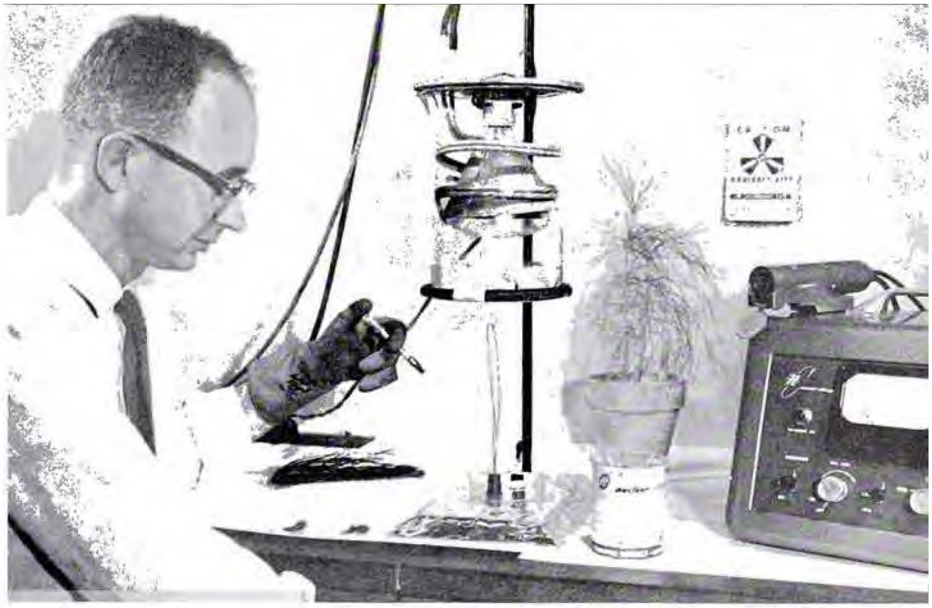


Figure 8.—Research in the physiology of flowering uses a number of methods to separate biochemical compounds; *A* illustrates a step in the two-dimension paper chromatography technique—a basic method used in identification and analysis of compounds in pine tissues. Complex mixtures are separated into individual compounds which appear as discrete spots on finished chromatograms. The step shown here involves adding the developing solvent to trays containing chromatograms.

B shows an ion-exchange column being used with an automatic fraction collector to separate amino acids in extracts of pine tissues. This technique handles much larger samples than does paper chromatography. Various amino acids wash through the resin column at different speeds and are collected in different test tubes.

Paper electrophoresis (*C*) is a technique used to separate compounds. An electrical potential maintained across the filter paper screen separates compounds according to their movement in the electrical field.

Figure 9. — Feeding radioactive amino acid solutions to loblolly pine needles and conelets to study physiological processes. Radioactive compounds formed in the tissues are identified by paper chromatography and autoradiography.



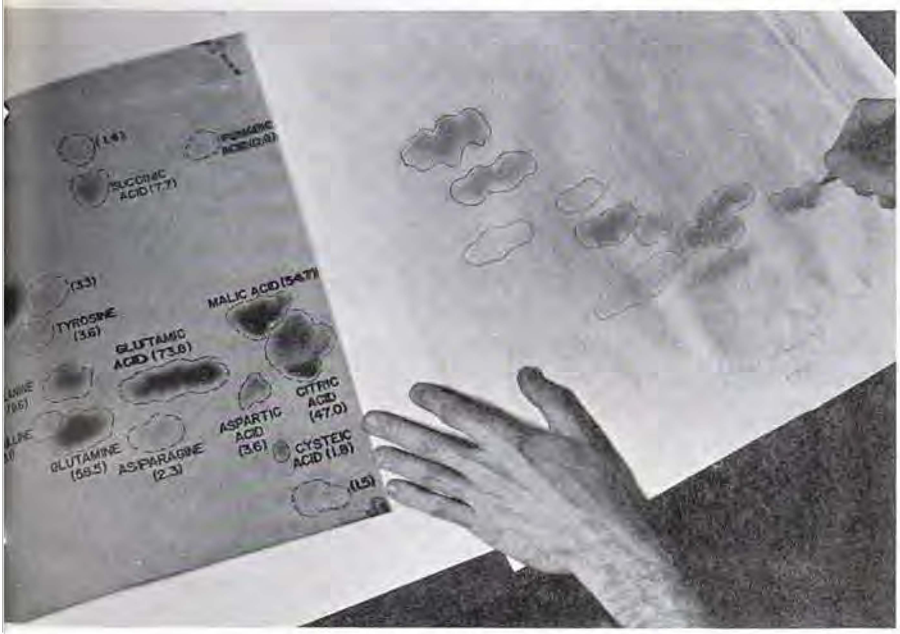


Figure 10.—Finished chromatogram (*right*) and autoradiogram (*left*) of pine needle extracts. The spots on the chromatogram were made visible by spraying the paper with a chemical reagent which reacts with amino acids. The spots are identified by the positions which they occupy on the chromatogram.

The autoradiogram is a sheet of X-ray film which has previously been placed in contact with a paper chromatogram and on which the compounds formed in a radiotracer experiment have been separated. The locations of radioactive compounds are revealed by the darkening of the X-ray film where it has been in contact with radioactive spots.

Figure 11. — Determining the amounts of radioactivity in compounds formed in pine buds during a radiotracer experiment. Radioactive compounds, which have been located by autoradiography with X-ray film, are counted by means of the Geiger tube (*center foreground*) connected to the scaling unit on left.

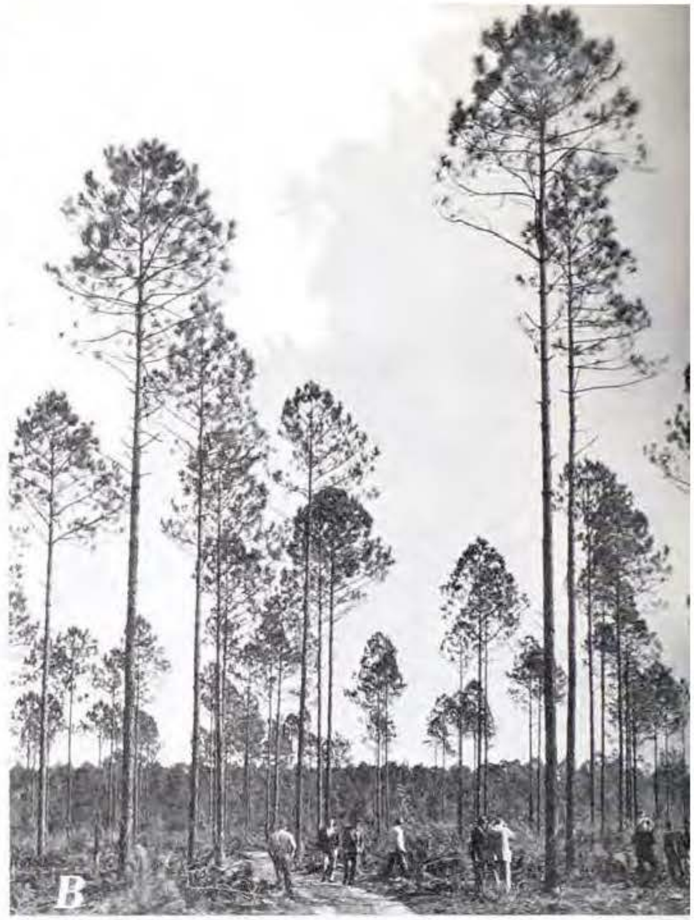
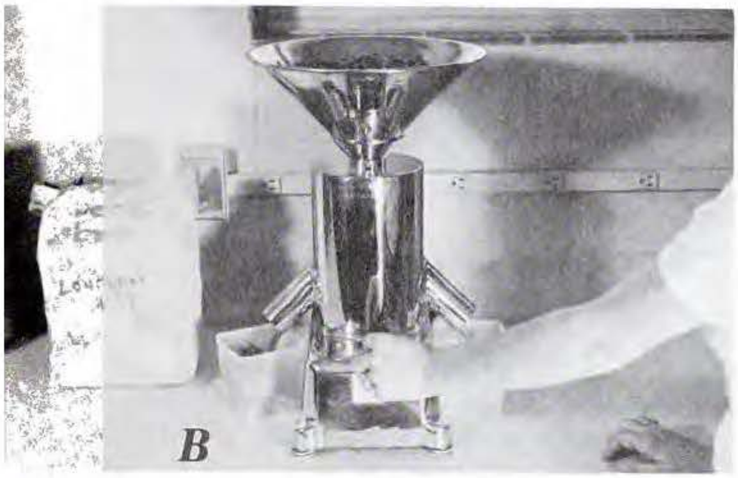


Figure 12.—After seed certification standards are devised, it is necessary to train inspectors and select seed-production areas. *A* shows examination of a tree on the first seed production area approved for certified seed. An over-all view of a portion of this area, owned by Continental Can Company in Emanuel County, Georgia, is shown in *B*. Certified seed (*C*) is the ultimate objective of the entire program.

Figure 13.—To establish seed orchards it is necessary to prepare root stocks (*A*) for grafting with scions from superior trees (*B*). The grafted stock is then outplanted in seed orchards (*C*), after which it grows rapidly. The material in *D* was field planted in the fall of 1955 by the Georgia Forestry Commission with technical assistance by the Macon Research Center. Here it is shown after 4 years in the field.



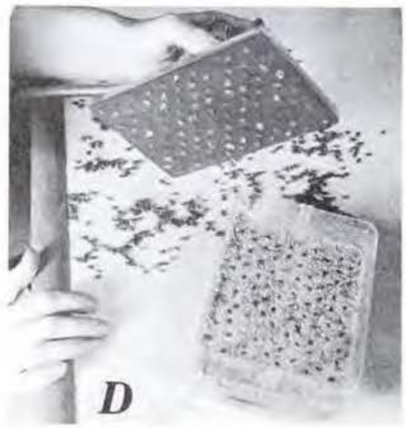


Figure 14.—The Seed Testing Laboratory at Macon, Georgia, (*A*) has both seed testing and seed research facilities, including (*B*) devices to mix and divide seed samples, (*C*) seed preparation equipment and facilities, (*D*) vacuum seed counters, and (*E*) germinating rooms with controlled temperature and humidity. A high degree of control can be maintained and accurate germination tests are the result (*F*).

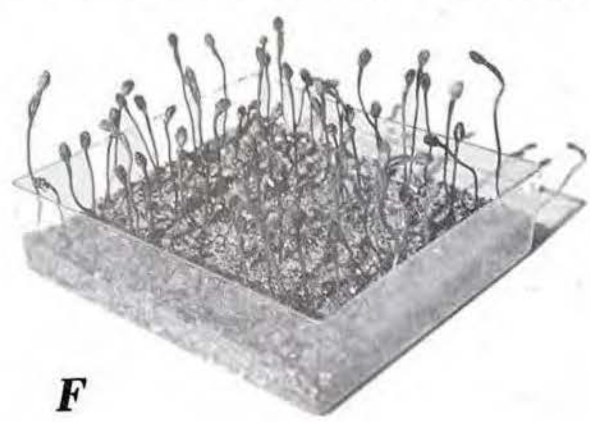


Figure 15.—Germination percent of longleaf pine seed as related to time of extraction. The date of receipt at the seed laboratory is correlated with the time of extraction of late seed; i.e., late sample receipt means late extraction at the nursery.

Figure 16.—Seed handling research. Germination is often reduced during seed extraction and handling, but the reasons for this reduction are not known. Some damage may be caused prior to drying (*A*) or during the extraction process (*B*), (*C*), especially by dewinging and cleaning action. Further reduction in germination occurs between the completion of the extraction process and actual planting of the seed.

PROGRESS IN USE OF SEED

Direct Seeding Slash Pine

Test areas in Collier County, Florida, were direct seeded to slash pine. This cutover pine land had a typical growth of sawpalmetto, gallberry, and wire grass. Part was chopped with a Marden brushcutter prior to planting and part was left in a natural condition.

Site preparation did not successfully affect seedling establishment or seedling growth up to 2 years under moderately dense cover conditions. Differences between three direct seeding rates, however, were highly significant (fig. 17)

In the south Florida area, on flatwood sites where the sawpalmetto cover is light to only moderately dense, site preparation is not required for the establishment of a stand of slash pine by direct seeding. However, where the sawpalmetto cover is dense (i.e., where the sawpalmetto has crowded out the wire grass) site preparation will be required for seedling establishment, fire hazard reduction, and to facilitate later cutting operations in the stand.

Early Planting of Slash Pine

Trials of early planting of slash pine near Lake City, Florida, show promising results. The normal planting season in this area is in the late fall and winter months. A study encompassed planting in summer and in winter to measure survival following earlier season planting.

Part of a group of seedlings grown from seed sown in March 1958 were outplanted in August 1958, and the remainder were outplanted in December 1958. Field survival and growth are shown below:

Outplanting (Date)	*Survival* * (Percent)	*Height at time of planting* (Feet)	*Height by July 1959* (Feet)	*Height growth* (Feet)
Aug. 20, 1958	80	0.95	1.42	0.47
Dec. 16, 1958	80	.98	1.23	.25

* As of July 1959.

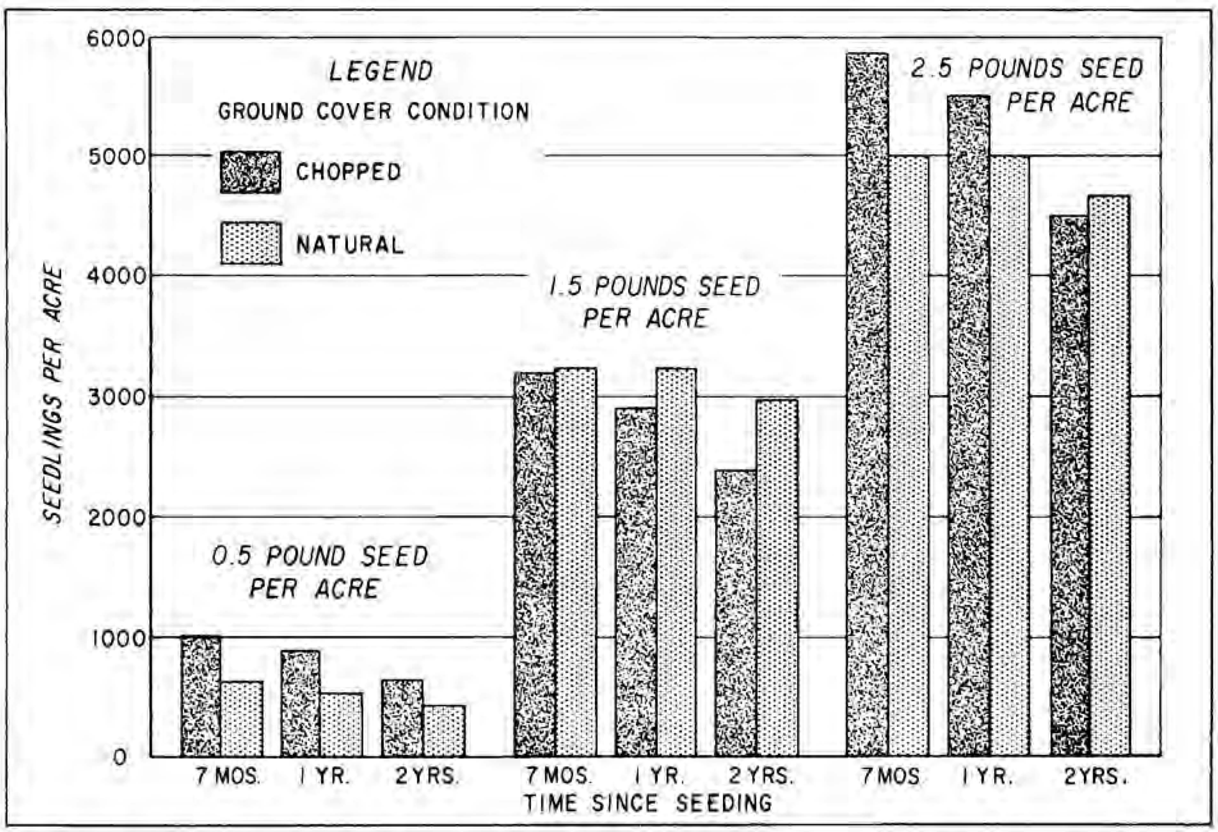


Figure 17.—Establishment of slash pine seedlings from seed in south Florida, sowed at three rates and with site preparation.

Satisfactory survival was obtained from late summer planting and the results suggest that the planting season might be altered. Success of the early planting may be explained by the fact that although summer temperatures are generally higher than winter temperatures, the amount of rainfall is usually higher and distribution better in summer than in winter in north Florida.

Seedlings planted in August 1958 stopped growing after outplanting, but then more than made up for this loss in the following spring. By July 1959, the trees planted earlier were taller than those planted at the usual time. Apparently, the seedlings planted early had become well established before the next growing season and had built up higher reserves of stored food for growth the following year.

Direct Seeding Bottom Land Oaks

Since 1952, studies in the direct seeding of cherrybark oak and Shumard oak have been under way at the Charleston center. Direct seeding showed definite promise under certain site conditions (table 4).

Seeding success can be improved by reducing the number of unsound acorns either by visual inspection (fig. 18), by hot water baths, or by fumigation before planting.

Effectiveness of seeding can be further improved by decreasing rodent depredations. Current studies are testing the use of various repellents on seed predators (fig. 19).

Table 4.—Average third-year survival and height growth of direct seeded oaks by site condition, Santee Experimental Forest [1]

Species	Cleared terraces		Released first bottoms [2]	
	Survival	Total height	Survival	Total height
	Percent	Inches	Percent	Inches
Cherrybark oak	23	23	5	13
Shumard oak	37	30	6	28
Average	30	27	6	20

1/ Summary of 1953, 1954, and 1955 study installations.
2/ Released after one growing season.

Figure 18.—Shumard oak acorns. Those with light colored cup scar (2 on right) are sound, and those with dull coloration (2 on left) show evidence of weeviling or rot.

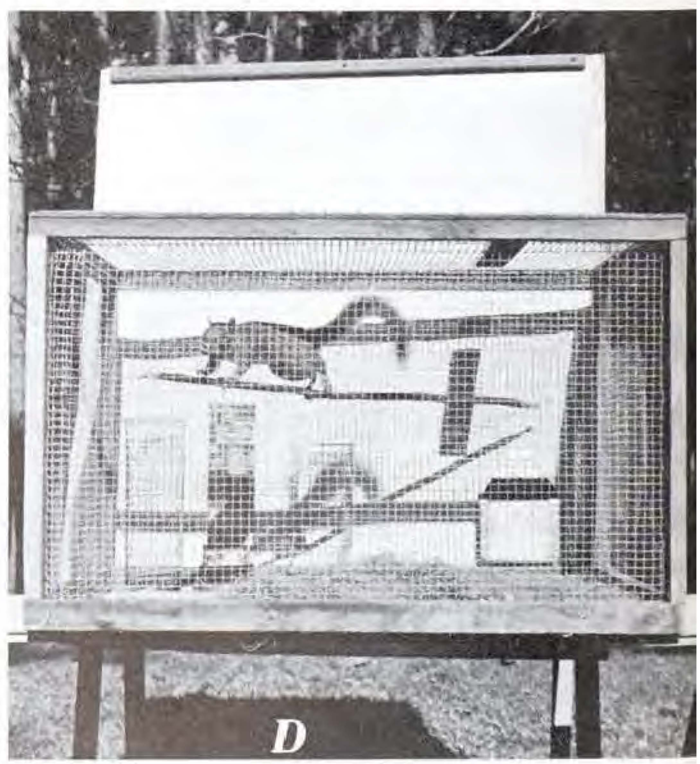


Figure 19.—To test reactions to various repellents applied to bottom land oak acorns, mice (*A*), cotton rats (*B*), and squirrels were trapped on the Santee Experimental Forest. *C* shows a squirrel becoming accustomed to corn bait. The feeding tests are carried on in large cages (*D*).

Direct Seeding Upland Oaks

Two tests of upland oak direct seeding were made in the Piedmont and mountains of North Carolina. In the Piedmont, white oak acorns were planted in the fall, and black and northern red oak acorns were stratified and the sprouted acorns planted in the spring. Screening helped survival, although no appreciable predator loss occurred in the open. All three species had satisfactory initial stocking from direct seeding. At the end of 2 years, white oak had the least mortality.

The mountain study with northern red oak involved variation in protection from predators, depth of planting, and season of planting. Fifty percent survival at the end of the first growing season was obtained by planting sprouted acorns 1 to 2 inches below the soil surface in the spring.

PROGRESS IN OTHER FIELDS

In addition to the seed research, several major projects were started in 1959. In south Georgia and north Florida, a study of the effect of site preparation upon planted slash pine survival and growth was undertaken with the cooperation of the Georgia Forestry Research Council, the Georgia Forestry Commission, St. Regis Paper Company, Owens-Illinois Glass Company, Rayonier, Inc., Union Bag-Camp Paper Corporation, and Brunswick Pulp and Paper Company. A cooperative study in south Florida involving the American Agricultural Chemical Company and the Babcock Florida Company is measuring response of native range vegetation and slash pine to different levels of rock phosphate fertilization. Direct seeding studies have been installed at Cordele, Georgia.

Two important research summaries were issued during the year. U. S. Department of Agriculture Production Report 30, "Sand Pine Regeneration on the Ocala National Forest," by Robert W. Cooper, Clifford S. Schopmeyer, and William H. Davis McGregor, answers problems associated with natural and artificial regeneration of a species which previously was successfully reproduced only following damaging wildfires. The relationships of soil moisture under forest cover, old-field vegetation, and bare soil in the Piedmont are the subject of U. S. Department of Agriculture Technical Bulletin 1207, by Louis J. Metz and James E. Douglass.

Another important contribution reported a growth study in young slash pine stands. Gruschow and Evans in *Forest Science* showed that in flatwood stands of Florida and Georgia maximum slash pine cubic foot volume growth is realized at less than full stocking, particularly on low sites (fig. 20). The analyses also show that, given time to readjust and occupy growing space, a stand of young slash pine trees will produce about the same volume growth over a fairly wide range of stocking.

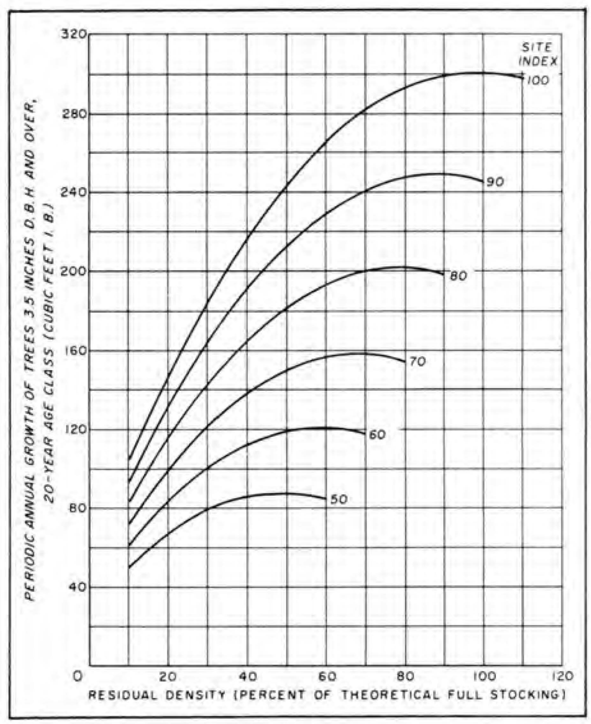


Figure 20.—Relation of periodic annual cubic-foot volume growth per acre to stand density and site quality in 20-year-old slash pine.

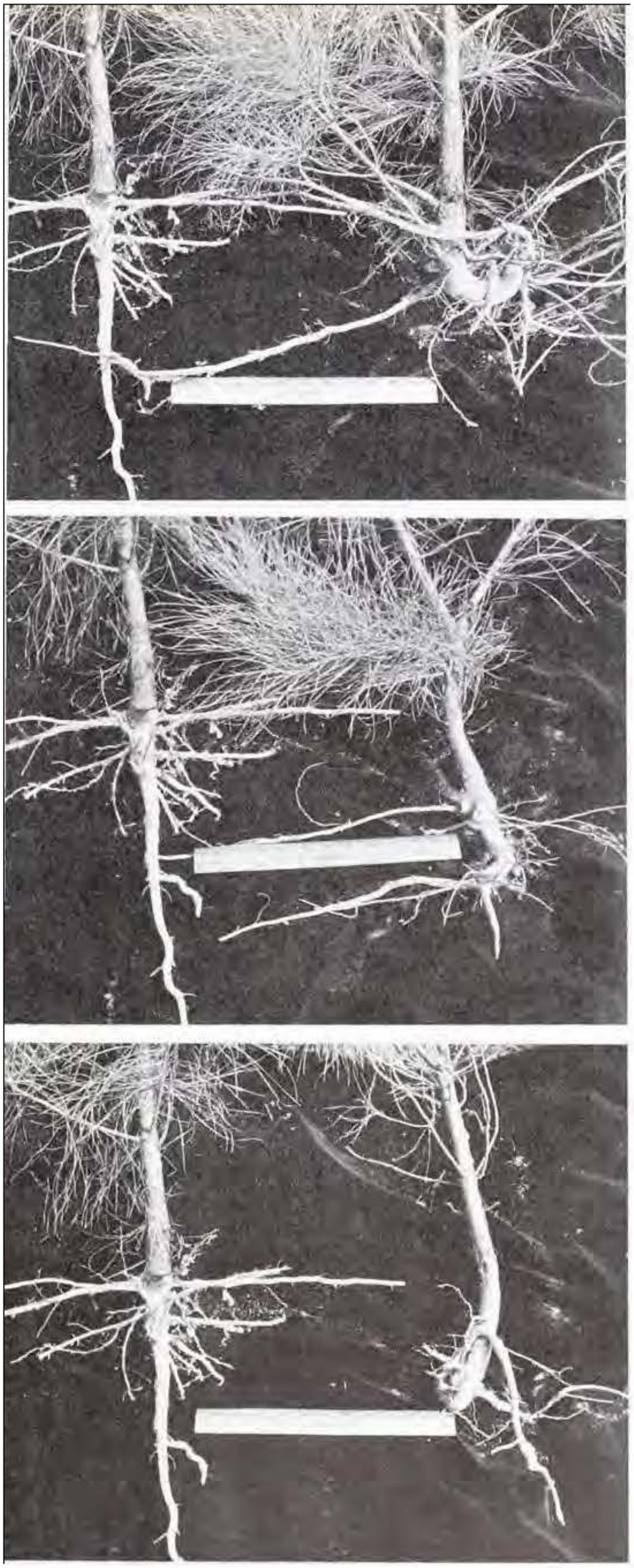


Figure 21.—Typical root systems of natural loblolly pine seedlings (*left*) and bar planted seedlings (*right*).

Artificial Regeneration

Forest plantings of loblolly pine.—A recent study of 3-year-old loblolly pine plantations in southeastern Virginia showed that 67 percent of the trees had malformed root systems caused by poor planting. These trees were bar planted on cutover forest land in 1954-55. Some of the taproots were bent upward, some of them were bent horizontally and were developed at right angles to the direction of a normal taproot, and some were so deformed or cramped that they almost defied classification (fig. 21). The effect of these deformities on the growing trees has not been evaluated, but previous experience has shown that deformed root systems are usually vulnerable to many hazards.

It was also found that forest planters did not make good use of seedling stock in many cases. Effectiveness was seriously reduced by four factors. Alone or in combination, seedling mortality, irregular spacing, overtopping by competition, and unplanned for natural loblolly pine seedlings reduced utilization of the planting stock. The average loss or ineffective use of planting stock is shown in the following tabulation:

	Per acre
Planted seedlings (estimated)	900
Survival at 3 years	579
Less seedlings clustered	68
Surviving seedlings well-spaced	511
Less well-spaced seedlings overtopped	91
Surviving well-spaced, free-to-grow seedlings	420
Less well-spaced, free-to-grow planted seedlings duplicated by free-to-grow natural pine	180
Effective planted seedlings	240

This tabulation points out the futility of evaluating success of forest plantations solely on the number of surviving planted seedlings. On these plantations the resulting natural pine regeneration often made planting unnecessary, and hardwood brush and surviving trees overtopped planted seedlings.

Silvics

Flooding kills yellow-poplar.—Late in 1955 an abandoned field in the overflow bottoms along the Oconee River in Greene County, Georgia, was planted to yellow-poplar. A number of times in the 4 years since establishment the plantations have been covered by highwater during the dormant season and were not damaged. In late May 1959 heavy rains caused an overflow that flooded the plantations for 4 days (fig. 22). One hundred percent kill of tops occurred in some plantings, with mortality as high as 95 percent (fig. 23).

The field results confirmed a controlled study of season and duration of flooding of seedlings planted in small tanks. Seedlings withstood floodings during the growing season for 3 days with little mortality or loss of growth, but extending the period increased mortality until all were dead after 14 days.

Yellow-poplar fertilization.—Three rates of diammonium phosphate (20-52-0) were broadcast over yellow-poplar plantations shortly after outplanting on a soil low by agricultural standards in nitrogen, phosphorus, and potassium. Height growth on the fertilized plots was greater than on the check plot during both of the first 2 years following application (fig. 24). The results of the second-year measurements showed that the effect of fertilization was not falling off, but rather that the gap between the treated and control plots had widened (fig. 25).

Figure 22.—Yellow-poplar planting flooded to a depth of 3 feet in May 1959.

There also were marked differences in foliage color. During the growing season the experiment resembled a checkerboard: rank, dark green foliage on fertilized plots contrasting with sparse, pale green growth on the controls.

Figure 23.—The top of this yellow-poplar was killed, but the sprouts from the root collar indicate that the root system is still alive.

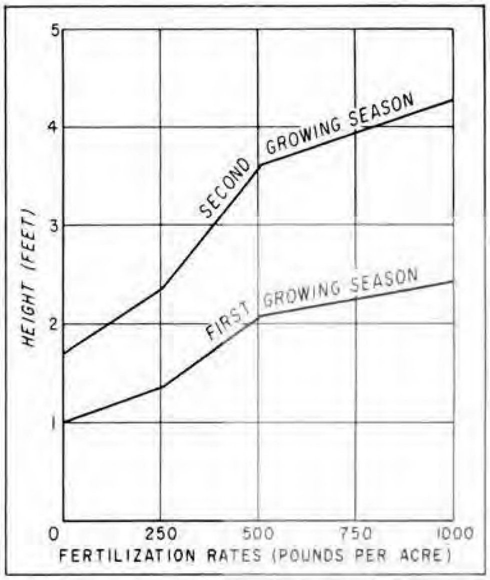


Figure 24. — Average height of yellow-poplar seedlings at the end of the first and second growing season with varying applications of diammonium phosphate fertilizer.

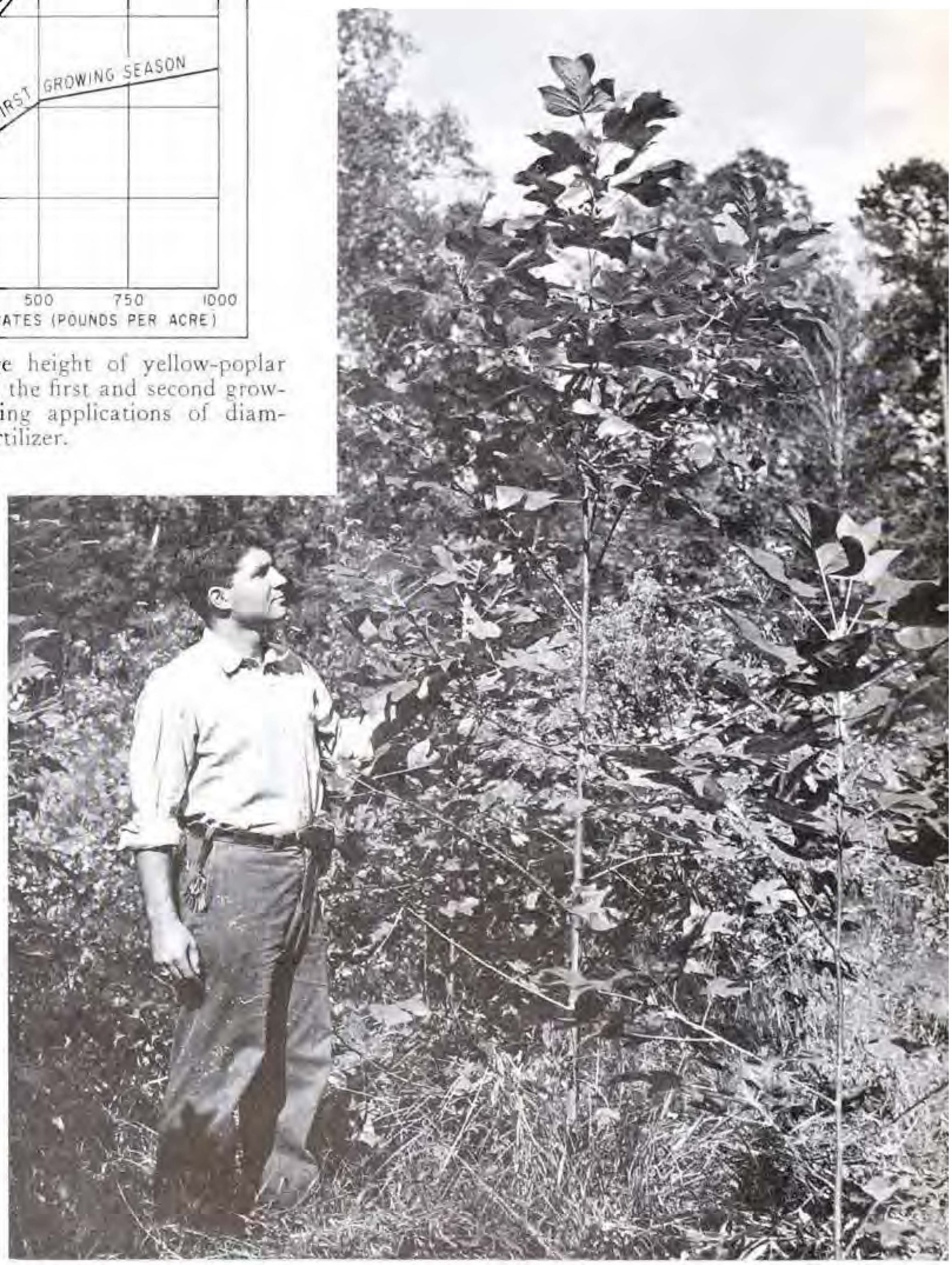


Figure 25.—Many trees grew over 7 feet in height in 2 years following application of diammonium phosphate fertilization at the rate of 1,000 pounds per acre.

Financial Aspects

Grade yields of second-growth yellow-poplar.—Four studies of second-growth yellow-poplar conducted in western North Carolina showed that hardwood log and tree grades can be satisfactorily applied to standing trees.

These studies indicated that site affects the quality of upper grade second-growth yellow-poplar. For example, a 20-inch, grade A two-log tree from site index 120, an excellent site, proved to be worth $52.50 per M stumpage while one from site index 80, a fair site, is worth $40.00 per M stumpage.

Stumpage values for second-growth yellow-poplar rank favorably with other commercial species in the area and show a rapid increase in value with increasing diameters (table 5).

Table 5.—Stumpage values [1] per M board feet by size for tree grades A and B on good sites (site index 100) (Dollars per M board feet)

D. b. h. (inches)	2-log trees	
	Grade A	Grade B
16	37.50	20.00
18	42.50	27.00
20	46.00	31.50
22	49.00	36.00
24	50.50	39.00
26	50.00	40.50

1/ Values based on No. 1 common lumber at $115 per M board feet, less 12 percent for profit and risk, less logging and milling costs.

Naval Stores

A new yield table for first-year gum yields shows expected yields for ¾-inch, acid-treated streaks on slash pine (table 6). It shows expected yields from trees with faces equal in width to one-third of the tree circumference and ¾-inch bark-chipped streaks sprayed with 50-percent sulfuric acid. The yields are from faces worked biweekly by well-trained labor using the best chipping and spraying techniques.

A test of gum production in south-central Florida showed that South Florida slash and longleaf pine can produce a volume of gum equivalent to that obtained from comparable timber in other sections of the naval stores belt. The application of streaks before the middle of March did not appear to be profitable, but chipping and treating through October for both species were justified and economically feasible. Analyses of oleoresin showed that rosin and turpentine content were within the percentage range expected and the physical and chemical characteristics of the rosin were commercially satisfactory.

Table 6.—First-year gum yields [1] from single-faced slash pines for six diameter classes and five crown ratio classes

D. b. h. (inches)	Gum yields by crown ratios of--				
	0.20	0.30	0.40	0.50	0.60
	- - - - - - - Barrels - - - - - - -				
9.0	172	190	208	226	244
10.0	209	227	245	263	281
11.0	246	264	282	300	318
12.0	283	301	319	337	355
13.0	320	338	356	374	392
14.0	357	375	393	411	429
15.0	394	412	430	448	466

1/ In barrels (435 pounds) of gum per crop of 10,000 faces obtained from 16 biweekly streaks; no advance streak applied.

FOREST DISEASES

In many ways 1959 has been a year of accomplishment in forest disease research. Major nurseries of the Southeast now fumigate their soil, and are being rewarded by increased production and better quality seedlings. Effective experimental control of cone rust has been achieved, and prospects are good for practical control for seed orchards.

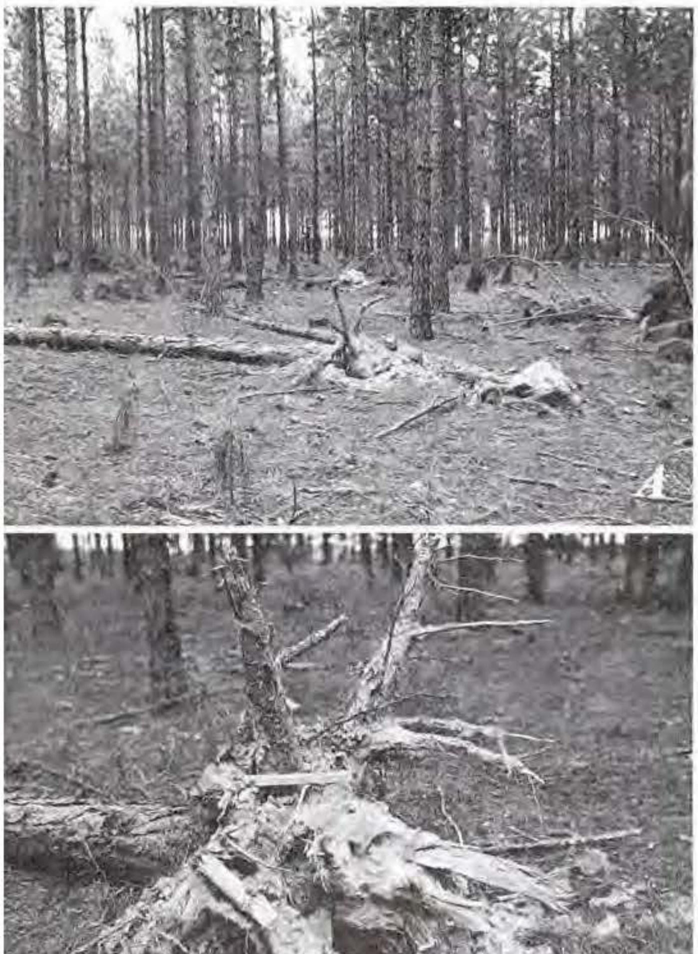


Figure 26.—Blowdown of planted slash pine by Hurricane Gracie in South Carolina. (*A*), Several trees overturned because their roots were rotted by *Fomes annosus*. (*B*), This tree's taproot and several laterals were badly rotted.

A series of oak wilt control appraisal plots are being accumulated that, within a few years, should go a long way toward telling us what we are accomplishing in the state-operated control programs. Important new information has been gained on the localized spread of oak wilt and *Fomes annosus*. Means of identifying several different kinds of white pine needle blights have been developed, although the causes of some remain in doubt.

On the basic research side, techniques for studying the role of mycorrhizae in southern pine nutrition have been developed and, through the use of aseptic cultures of pine seedlings, a mycorrhizal relationship has been proved for several fungi. Pine tissue cultures are being grown in connection with rust studies, and a means of separating organisms in mixed cultures, such as soil dilutions, by electrically induced pH gradients within a single solid-media plate has been demonstrated. The pathology staff authored 16 publications in 1959, and improved its facilities and equipment at the 5 locations where disease research is conducted.

During the past year, *Fomes annosus* became particularly conspicuous as a killer of slash and white pine in thinned plantations. Much windthrow from Hurricane Gracie was due to annosus root decay (fig. 26). The brown spot fungus heavily defoliated white pine in parts of North Carolina and Virginia. The pitch canker, so prevalent a few years ago on many pines, was relatively inactive except on shortleaf pine in one North Carolina county where it teams with an insect and causes material damage. The fungus *Dothiorella quercina* and the pit-making oak scale acting together caused considerable branch dieback in chestnut and white oaks in western Virginia during the past summer. The chestnut blight fungus continues to cause much cankering and killing of post oak in Tennessee. Also noteworthy, but not unusual, were many reports of dogwood leaf blights, Hypoderma needle blight on pine, littleleaf, white pine blight, and mimosa wilt. Each year better surveillance, better surveying, and better reporting give us more reliable estimates of disease occurrence, loss, and the effectiveness of control operations.

Nursery Diseases

Continued research has provided additional information on the serious black root rot problem in Southeastern nurseries, which is caused by species of Fusarium and Sclerotium. Seventeen tree species were grown in soil infested with the root rot fungi to determine their resistance to this disease. Disease reaction of 17 tree species to black root rot is as follows:

Highly susceptible (Species)	*Slightly susceptible* (Species)	*Immune* (Species)
Slash	Spruce pine	Arizona cypress
Loblolly	Redcedar	Baldcypress
Shortleaf		Eastern white-cedar
Longleaf		Sweetgum
Corsican		
Loblolly x shortleaf hybrid		
Sand		
Pond		
Virginia		
Maritime		
Aleppo		

Nemagon, a nematocide which can be safely applied around living plants, was tested against *Tylenchorhynchus claytoni*. Dosages of as little as one-half gallon per acre reduced the nematode population, but the population built up again within a few weeks. Dosages of more than five gallons per acre were necessary to bring and hold the population below damaging levels.

Preliminary investigations have been carried out on the summer chlorosis of nursery stock. The addition of an iron chelate containing 12 percent metallic iron, at 45 pounds per acre, has corrected chlorosis experimentally. Another interesting lead into the possible causes of chlorosis was provided by tissue analysis. Chlorotic needles were higher in calcium than healthy needles. Further work on summer chlorosis is under way.

A disease of eastern redcedar caused by *Exosporium glomerulosum* has been responsible for heavy losses in several plantations in the eastern part of North Carolina. This disease, not previously reported from this area, has also been found in Virginia and South Carolina. Severe infection has been noted in some young plantations, with 10 to 15 percent mortality common. Heavily infected trees are unfit for sale as Christmas trees. Infection usually begins on the lower branches and progresses upward and outward. In severely infected trees, only the needles at the tips of the branches remain alive (fig. 27).

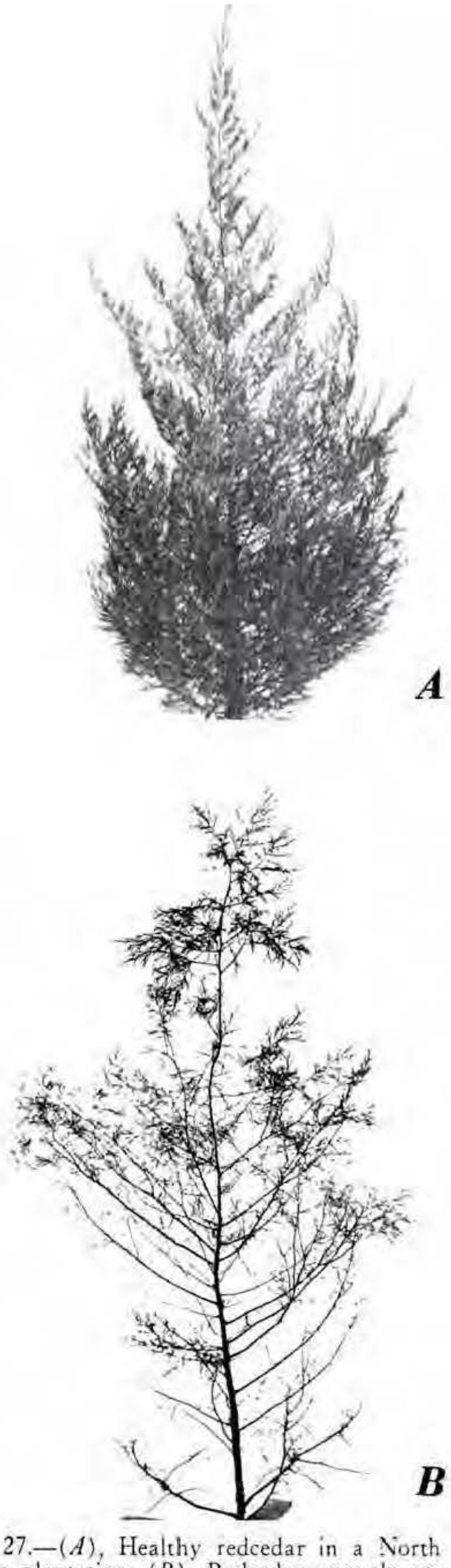


Figure 27.—(*A*), Healthy redcedar in a North Carolina plantation. (*B*), Redcedar severely attacked by Exosporium blight.

Another distinguishing characteristic of the disease is the large number of juvenile needles (fig. 28). The fruiting bodies of the causal organism appear as black dots on the upper surface of the infected needles.

There are indications that Exosporium blight can be controlled with biweekly applications of Phaltan at 2 pounds per 100 gallons of water. Close proximity of several diseased and healthy trees in plantations may indicate resistance to the disease by some individuals.

Phomopsis blight was also severe on 2-year-old redcedars in plantations this year. In contrast to Exosporium blight, this disease causes the death of needles at the ends of branches. Two plantations were complete losses, and heavy mortality was reported in several others. Losses from Phomopsis blight, coupled with injury from *Exosporium glomerulosum*, may make the production of redcedar Christmas trees difficult in the Middle Atlantic States.

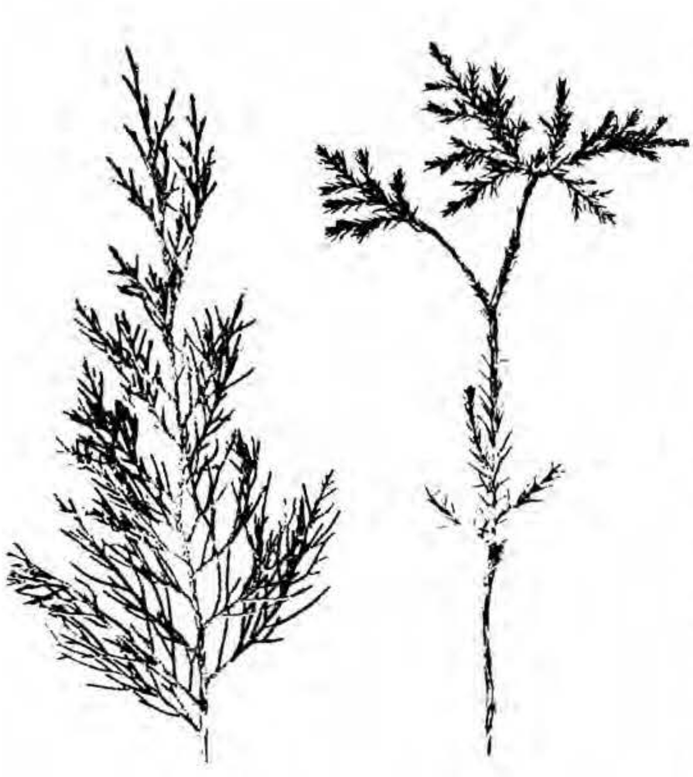


Figure 28.—*Left*, Healthy redcedar shoots. *Right*, Shoot with Exosporium blight. Note juvenile needles.

Cone Rust

Significant advances have been made during the past year on the cone rust of slash and longleaf pines caused by *Cronartium strobilinum*. A survey of the cone rust situation in the commercial slash pine area of Georgia and Florida revealed that the heaviest damage was in north central Florida. An abrupt drop in the incidence of cone rust in south Georgia coincided very closely with the northern limits of live oak, one of the most important alternate hosts of this fungus. This correlation indicates that live oaks in the vicinity of seed orchards and seed-production areas may be the most important source of inoculum, but other evergreen oaks are also important. Slash pine seed orchards might best be established north of the live oak range wherever possible.

Direct control measures will often be advisable within the area of high cone rust hazard. Ferbam, at a concentration of 2 pounds per 100 gallons of water, with a spreader-sticker, gave good protection against the disease (fig. 29). Conelets were susceptible to infection during the developmental stages from late twig bud until just after the period of pollen receptivity. To obtain satisfactory protection for the conelets during this period, the fungicide must be applied either before or immediately after each 18-hour or longer period of high relative humidity (over 85 percent) or rainfall.

Ferbam not only controlled the rust, but also stimulated pollen germination. Actidione, at concentrations of 1, 5, and 25 ppm., was toxic to strobili, particularly during the stages immediately preceding pollination, and had little effect on the rust.

Blister Rust Control

Over 6.5 million white pine seedlings were distributed from North Carolina nurseries during 1959, and most of these seedlings were used for plantings in the mountainous section of the State. Because many of these plantations are above 3,000 feet in elevation, and because ribes plants are found primarily at these higher elevations, the blister rust problem may increase. One-fourth of all private plantings have been made within high-hazard zones near ribes, and last year 13 new locations of blister rust were found on native and planted white pine in western North Carolina.

Care must be exercised in locating plantations away from ribes, or in areas where nearby ribes have been eradicated. Only in this way will the control forces of the States and Forest Service be able to hold blister rust losses to a continuing satisfactory low level.

White Pine Blight

This disease, or disease complex, can occur wherever eastern white pine is grown. Symptoms vary considerably and may involve tipburn, needle shortening, chlorosis of needles, reduced shoot growth, premature death, or any combination of these symptoms.

Two and one-half years' data are now available from 14 study plots, each containing 40 dominant or codominant trees, established in 1957. Four of the plots were in the Kingston, Tennessee, area and the remainder were located in Tennessee, Virginia, and West Virginia. There has been higher mortality in the four Kingston plots than in the other plots. The average mortality in these four plots has been 3.7 percent since plot establishment, while only one tree has died of blight on all plots outside this area.

Figure 29.—Spraying for cone rust control, Lake City, Florida, winter 1958-59.

On plots located outside the Kingston area, needle tipburn has occurred only during late spring and summer while the needles are still immature. In the Kingston area, some tipburn occurs at this time but some also occurs during the period from July through the following March. This indicates that there may be two diseases in the Kingston area. One seems to be similar to the emergence needle blight which occurs wherever white pine grows, and the other could be termed a post-emergence needle blight. These two conditions are distinct from the known fungus needle diseases of white pine.

Root systems of white pine suffering from needle-blight have been compared with root systems of trees from healthy areas. There were more dead tips and dead laterals on roots of blighted trees than on roots of healthy trees. In eastern Tennessee, many of the main roots on blighted trees are partially or completely dead. Approximately 1,300 isolations were made from healthy and diseased white pine roots. Twenty-seven genera of fungi have been identified, but in no case was any one organism consistently associated only with the blighted trees, and none of the fungi isolated was a known root pathogen.

A grafting study has been started using the following scion-stock combinations: healthy on diseased, diseased on healthy, and diseased on diseased. Grafted scions, either with or without needle blight, tend to remain in their original condition regardless of the condition of the stock to which they are grafted. This indicates that an above-ground factor is involved in needle blight, and also further substantiates the strong indications that individual trees differ in their resistance to the white pine blight complex.

Mycorrhizae of Southern Pines

The study of the mycorrhizal relationship between four species of southern pines and various mushroom fungi is being continued. Pine seedlings are grown under aseptic conditions in combination with suspected mycorrhizal fungi (fig. 30). Table 7 gives the results obtained with 17 of these fungi on the four species of pine. In this table a dash indicates that an association was tested but not confirmed. Questionable means mantle formation on bifurcate root tips, but no evidence yet of hyphal penetration and Hartig net formation.

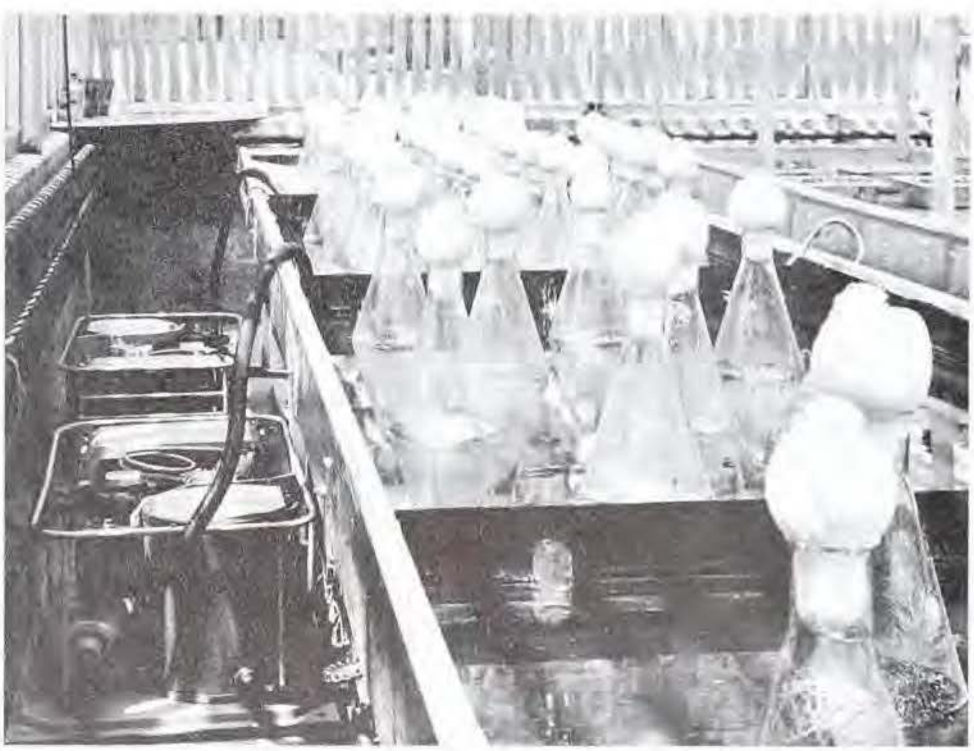


Figure 30.—Thermostatically controlled equipment, at left, cools and recirculates water around flasks in which pine seedlings and suspected mycorrhizal fungi are being tested under aseptic conditions of growth.

Table 7.—Fungi that produce mycorrhizae with pine

Fungi tested	Pine species tested			
	Shortleaf	Loblolly	Slash	Longleaf
Amanita muscaria	--	Positive	--	--
Armillaria mellea	--	Negative	--	--
Boletus betula	Negative	Negative	Positive	Negative
Boletus communis	--	Positive	Positive	Negative
Boletus rubropunctus	Negative	Negative	Negative	--
Boletus sp.	--	Positive	Positive	Positive
Clitocybe laccata	Positive	Positive	Positive	Positive
Clitocybe piceina	Positive	--	--	--
Clitocybe tabescens	Negative	Negative	Negative	Negative
Cortinarius albidipes	--	Negative	Negative	--
Hypholoma sp.	Negative	Negative	--	--
Lepiota procera	Negative	Questionable	Negative	Negative
Lycoperdon sp.	--	Negative	Negative	Negative
Pisolithus tinctorius	Positive	Negative	Negative	Questionable
Psalliota campestris	--	Negative	Negative	--
Lactarius sp.	Positive	Negative	Negative	--
Unknown agaric	Negative	Negative	Negative	Negative

Tests of agar enrichments are being made for the purpose of increasing the number of mushroom fungi that can be isolated in culture. Different culture media are also being tested in an effort to induce sporophore formation in culture. Increased rate of growth has been shown by some fungi grown on humus extract agars, but no species grow on them that will not grow on ordinary malt agar. No fruiting has been obtained except in one test flask culture of *Boletus communis* and slash pine.

Last spring a test was begun to determine the effect of mycorrhizae produced by six different mycorrhiza-forming fungi on the nutrition of various southern pines. Three months after the test was under way sporophores of *Thelephora terrestris* emerged in all tanks, possibly indicating incomplete soil sterilization. Prior to this time, roots of seedlings in the uninoculated control tank were free of mycorrhizae, but now well-developed mycorrhizae were present on roots of the pines. This indicated that *T. terrestris*, common in pine stands of the Piedmont and coastal plain regions, is an important mycorrhiza-former. Despite this contamination, differences in seedling growth were apparent between the various combinations of fungi and pines. Results from this test are not yet complete.

An electrochemical method of producing a fixed, wide-range pH gradient, from about 2 to 10, in agar media has been developed. The gradient is achieved by passage of a weak direct electric current (0.05 ma.) through the agar substrate for periods up to 72 hours. Possible uses include pH studies of microorganisms and tissue cultures of plants and animals, and separation of fungi and bacteria from mixed cultures, such as soil and diseased tissue (fig. 31).

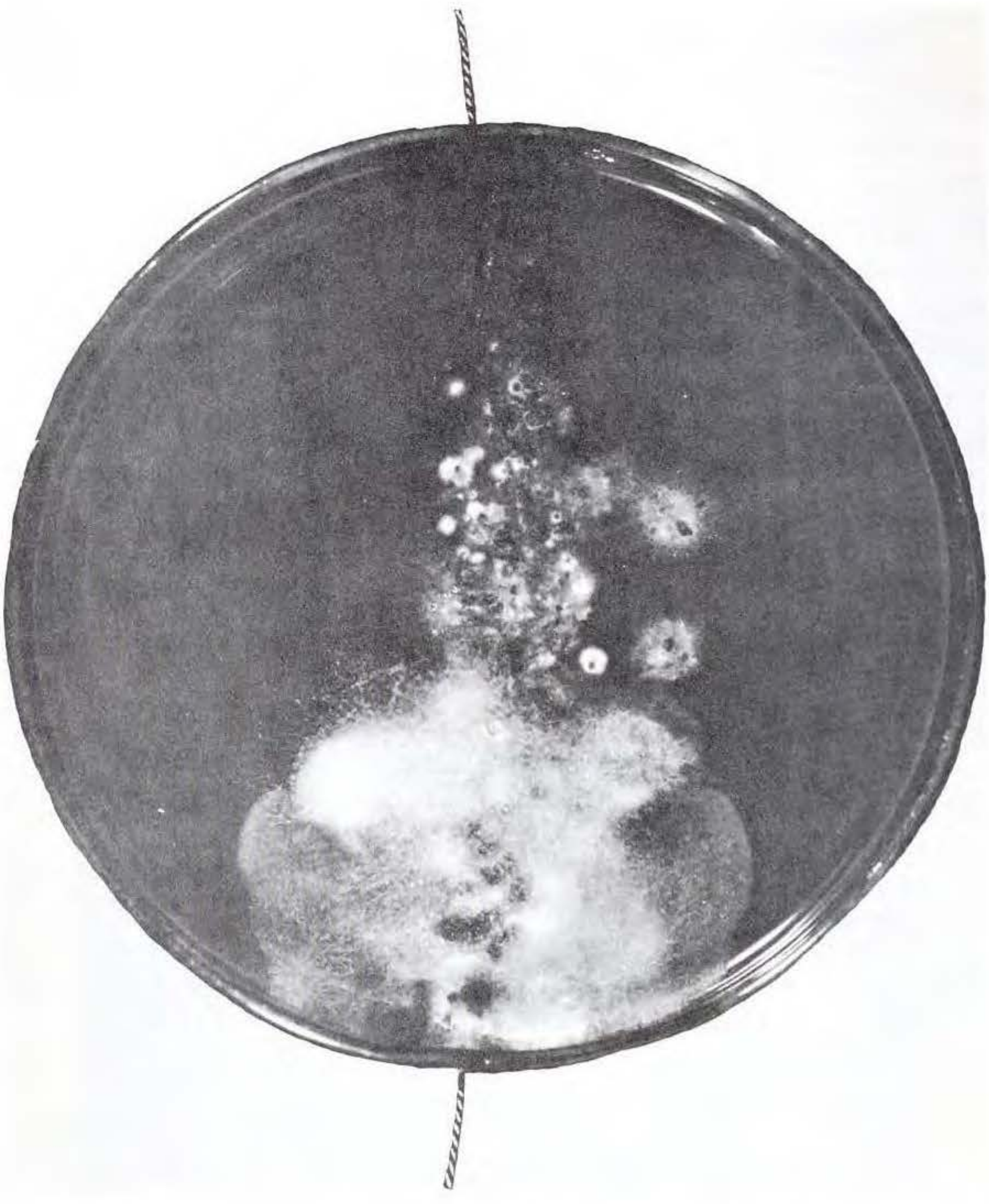


Figure 31.—A direct current is passed through agar for 41 hours. Forest soil is then sprinkled along the electrode path. This photo was made two days after inoculation. The top electrode is positive (pH 2); the bottom electrode, negative (pH 9).

Fomes Annosus Root Rot

Fomes annosus in thinned plantations of white and slash pine has caused increasing concern in recent years. With the large number of plantations now reaching thinning age, this disease may well develop into one of our more important problems.

Research on the means of spread of *F. annosus* revealed that both grafts and mere contact between diseased and healthy roots can transmit the disease (table 8). In another study, typical infections resulted within 12 to 16 months after inoculated root sections were placed against large uninjured roots of 12-year-old white pines. These results agreed with earlier findings that once *F. annosus* became established by infecting fresh stumps it was capable of spreading via roots into nearby healthy trees.

Exposures of agar plates within one badly root-rotted stand where *F. annosus* fruiting bodies were prevalent showed that viable spores were present in the air during every month of 1959. There were fewer spores during the summer than during other seasons. Some of the individual fruiting bodies examined produced spores throughout the year, while others were irregular in spore production.

Oak Wilt

In 1958 and 1959, 42 currently wilting oaks in western North Carolina were sampled by culturing all lateral roots of each tree about 1 foot from the stem. Each tree was within 30 feet of a wilt-killed oak. Forty-six roots of 23 trees contained the wilt fungus near the stem. Root grafts probably served as pathways of infection in only 1 of the 23 oaks examined, although these trees were within the root zones of previously wilt-killed trees. The presence of the wilt fungus in many nongrafted roots at appreciable distances from the stem could be explained only by either the movement of the fungus into the roots from the stem, or the fungus moving directly into the roots by some means other than through grafts. In the case of the 19 infected trees from which the fungus could not be isolated from any of the roots, the implication would be that either some infected roots were missed or that infection did not take place through the root system at all.

The intensive surveys for wilt in two counties in eastern Tennessee continue to yield information on the efficiency of the "felling and spraying" control method. Data collected during the years 1954, 1958, and 1959, when both Greene (control) and Washington (no control) Counties had 100-percent survey coverage, make possible a comparison between treated and untreated areas. In 1954, the year before treatment began in Greene County, there was slightly over 1 new infection center per 100 square miles in each county. The average for 1958 and 1959 is 4.3 in Greene and 9.2 in Washington County. Thus, even though the disease continues to spread (fig. 32), it is encouraging that the rate of spread in the treated area is less than half that in the untreated county.

The East-wide program of post-control appraisal is now in its second year. Critical evaluation of these plots should furnish valuable information on the effectiveness of the various control measures now being used. Forty treated and 29 untreated plots have been established in the southern Appalachians. A meaningful comparison of these plots is not yet possible, since only one year's results are now available.

Table 8.—Root grafts and root contacts as avenues for *Fomes annosus* spread between white pines

Stand description	Infected trees examined	Infected roots examined		
		Total	Root transmission through--	
			Graft	Contact
		Number		
Natural, 35-65 years old	6	18	5	5
Planted, 31 years old	11	44	14	7

Figure 32.—A large group of oaks killed by wilt in east Tennessee.

Littleleaf

In 1953, twelve lots of shortleaf pine seedlings grown from seed collected from different geographic sources within the natural range of this species were planted in South Carolina, Virginia, and Georgia, on severe littleleaf sites. The trees are being observed for possible resistance to littleleaf. Height data recorded after the sixth growing season in the field revealed no great differences between sources because of much variation within sources. Best growth, however, is represented by the Nevada County, Arkansas, source and poorest growth by sources from Pennsylvania and Texas.

In 1940-41, twenty-seven plots, distributed from Virginia to Alabama, were established to study the onset and development of littleleaf over a period of years. Nine plots were in severely diseased stands, 9 in moderately diseased stands, and 9 in healthy stands. Sixteen years later the losses from littleleaf were very high (table 9), showing that much of littleleaf belt will have to be operated on a short rotation for shortleaf pine.

Table 9.—Decline from littleleaf after 16 years in 27 plots of shortleaf pine

Plot condition in 1941	Trees diseased in 1941	Trees dead in 1957	Trees dead or diseased in 1957
	- - - -	Percent	- - - -
Healthy	1	25	49
Moderately diseased	12	29	75
Severely diseased	33	62	86

FOREST ECONOMICS

Field work on the third Forest Survey of Florida was completed in 1959, and Georgia's third Survey was begun on August 1. By December 31, plot data had been collected in 17 of the State's 159 counties (fig. 33). Remeasurement of sample plots established during the 1950-53 Georgia inventory is expected to increase the accuracy of estimates of timber cut and tree mortality.

An innovation on the Georgia survey is the use of "area condition classes" for evaluating present and potential forest productivity. A systematic arrangement of point-samples at each Survey plot provides this classification and indicates the type of silvicultural treatment, if any, that is needed.

Electronic data processing machines are being evaluated for speeding Forest Survey computations. A test was made to compare relative efficiencies of two electronic computers for processing Florida Forest Survey statistics. Three members of the Division attended a Forest Service conference in Atlanta to discuss new opportunities for adapting automatic computers to the solution of forest inventory and management problems.

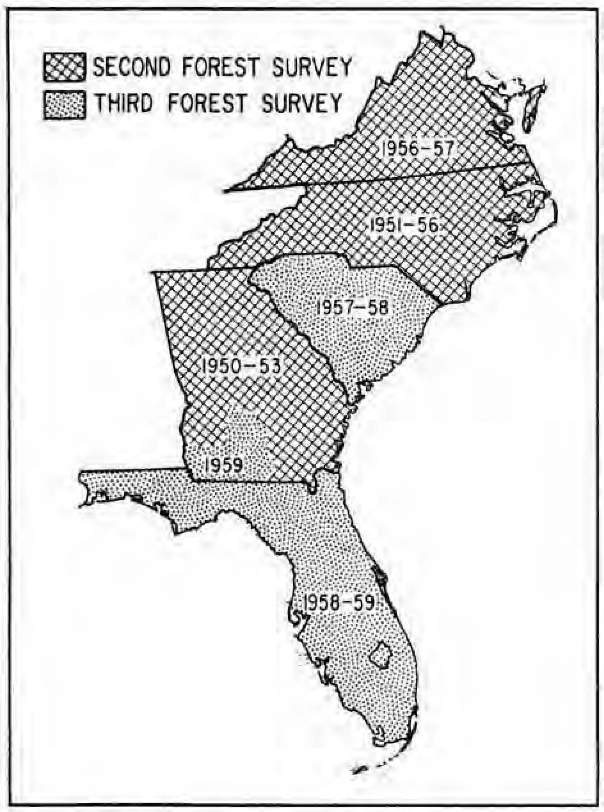


Figure 33.—Status of forest survey field work in the Southeastern States.

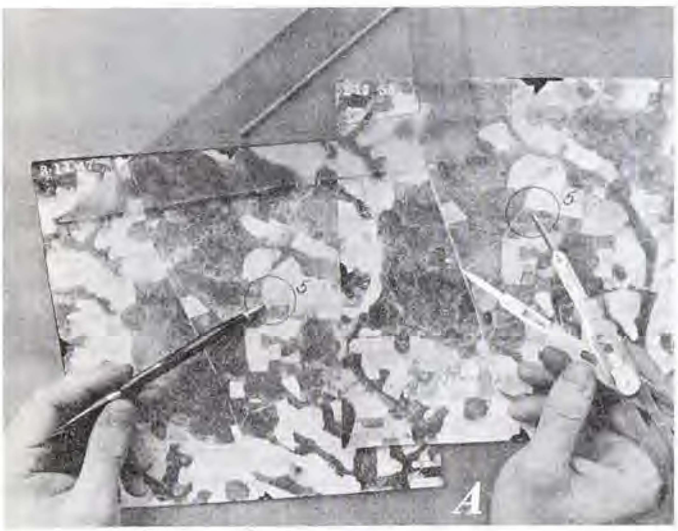
A national Forest Survey-Timber Management meeting was held in San Francisco in November. Divisional representatives presented technical papers on "Improving Accuracy of Volume Tables," "Long-term Growth and Volume Projections," and "Procedures for Integrating Field and Photo Estimates of Area and Volume."

A 100-percent production canvass was made of Florida wood-using industries, along with a study of fuelwood and fence-post production. Results will be published in a report during 1960. Also completed in the past year were the annual surveys of southern pulpwood production and prices, conducted in cooperation with the Southern Forest Experiment Station and the Southern Pulpwood Conservation Association. The production data were published as Forest Survey Release 82 of the Southern Station. Another cooperative project with the Southern Station involved the preparation of tree species distribution maps for 11 important conifers of the South. These maps are to be published early in 1960.

A new study in the economics of forest management and cultural treatments (thinning, girdling, site preparation) was started with the cooperation of Duke University. The first phase of the project, a library search for input-output data, was conducted by a graduate student as a thesis problem. As a follow-up, Duke Professor James G. Yoho visited southeastern forest industries, state forestry departments, and schools of forestry in search of unpublished input-output data.

As one result of an industrial development study in the North Carolina Piedmont, the State Extension Service and the Southeastern Station are publishing a series of timber marketing guides for each of 8 counties in the study area. These guides include names and addresses of wood purchasers by type of product, the specifications under which they buy, and other information of value to prospective sellers.

The Asheville staff was saddened by the untimely death in February of James F. McCormack, Chief of the Division of Forest Economics Research. Jim had been with the Forest Service for 24 years and had worked for the Southeastern Station since 1945. A. S. Todd, Jr., is now Acting Chief of the Division. A new addition to the Forest Survey staff is Dr. Gene Avery, who transferred from Washington, D. C., in July. Avery is in charge of Survey computations and will carry out special studies in forest aerial photogrammetry. Two men, Don Steensen and Joe McClure, are now taking graduate studies at Duke University.



THE FOREST SURVEY IN BRIEF

A. Permanent plot locations are transferred from aerial photographs used on the previous Survey to current prints by proportional dividers. Field crews use the new photos to locate the exact sample point on the ground.

B. A special graduated steel tape is used to define the limits of the variable-radius sample plot upon which tree tallies are taken. Field data are entered on plot sheets by numerical codes.

C. After field plot sheets have been double-checked for errors, coded entries are punched into IBM cards to facilitate faster compilations.

D. When all punched cards have been verified and sorted according to plan, tabulations of tree and plot data are made on an IBM accounting machine. The final statistics to be shown in published Survey reports are developed from these tabulations.

Many Opportunities to Increase Productivity of Forest Land in South Carolina

On over half of the commercial forest land in South Carolina much of the timber growing capacity is being wasted. Only 29 percent of this forest area is well stocked with pine (table 10). This commercial forest land includes 3.2 million acres of lowland hardwood types. Forest industries must depend on these lands for the main supply of high quality hardwoods, and yet only half of this area is well stocked with hardwoods of high enough quality to make saw logs, now or prospectively. Even in these better stocked stands productivity could be further increased by thinning overly dense pine stands and by improving the quality and species composition of the hardwood stands.

Stands on 2.8 million acres of commercial forest land are medium to well stocked with pine or hardwood growing stock, but the outlook for further improvement in stocking is very poor because of the presence of such material as shrubs, culls, and low quality hardwoods. Stand improvement measures are needed on these areas.

A third or remainder of the commercial forest area shows very little promise of becoming well stocked with desirable timber in the near future. For the most part, this area does not have enough desirable timber on it to justify trying to improve the present stand; it needs regeneration. Included in this total are upland sites which are less than 40 percent stocked with pine. On about one half million acres less than 20 percent of the area is covered with unwanted vegetation and this area could be planted without site preparation. But most of this area with little or no prospective growth will require the removal of unwanted trees and shrubs before the area can be planted.

While most of this upland forest area is suited to growing pine, how much should be devoted to this purpose depends on the comparative need for pine and hardwoods. A small area of mountain sites and the most productive piedmont sites are probably better suited to growing hardwoods than pine. Also, other sites may be best utilized by growing a mixture of pine and hardwoods. For the most part the prospective need for hardwoods can best be met by increasing the productivity of the lowland sites which are not suited to growing pine.

In addition to this 4-million-acre backlog of forest land that could be planted to pine, if this seemed desirable in the light of prospective industry needs, there are 1.4 million acres of idle cropland, much of which, if past trends continue, will be available for timber production.

The bulk of the forest land which would profit from treatment is owned by farmers (table 11). This reflects mainly the large area in farm ownership in the State, but it also reflects the poorer condition of farm woodlands. Sixty-two percent of the farm woodlands are in need of treatment, compared to 46 percent of the publicly owned forest land and 48 percent of the forest land owned by forest industries.

Table 10.—Commercial forest area by major type of action needed to increase productivity, South Carolina, 1958

Type of action needed	Commercial forest area	
	Thousand acres	Percent
No action needed:		
Well stocked with pine	3,443.9	28.8
Well stocked with hardwoods	1,679.2	14.1
Total	5,123.1	42.9
Stand improvement:		
Pine stands	1,293.1	10.9
Hardwood stands	1,518.3	12.7
Total	2,811.4	23.6
Regeneration:		
Without site preparation	458.8	3.8
With site preparation	3,541.6	29.7
Total	4,000.4	33.5
Total	11,934.9	100.0

Timber Cut and Mortality Estimates in Georgia

With the start of the third Forest Survey of Georgia in August 1959, remeasurement of permanent sample plots became the basis

Table 11.—Commercial forest area needing treatment by type of ownership, South Carolina, 1958

Ownership	Total	Needing treatment	
	Thousand acres	Thousand acres	Percent
Public:	1,034.4	476.8	46
Private:			
Forest industry	1,672.5	796.7	48
Farm	6,827.2	4,204.7	62
Miscellaneous private	2,400.8	1,333.6	56
Total	10,900.5	6,335.0	58
Total	11,934.9	6,811.8	57

for estimating average annual volume of timber cut and mortality. All trees that were 3.0 inches d. b. h. or larger at the time of the 1950-53 Survey were identified. Those cut or dead were tallied by species, size, class of material, and cause of death. Examination of the field records for the first 660 plots remeasured in Georgia showed that 50 percent were disturbed by cutting and 24 percent by mortality during the 9-year period between Surveys.

Plot remeasurement has the following advantages over former methods of estimating timber cut and mortality:

1. Estimates are not affected by the reporting errors that may bias production surveys based on canvasses of timber operators and wood-using industries.
2. Plot remeasurement provides an accurate estimate of changes resulting from cutting and mortality. Previous estimates based on stump and dead-tree counts were suspected of being too low because of missed stumps and overestimation of the period since cutting or death.
3. Remeasuring plots at 5- to 10-year intervals provides estimates of average annual cut that are not unduly affected by temporary conditions, such as short business booms or recessions, droughts, and damage from a single hurricane. Conversely, the shorter periods required for accurate stump and dead tree counts on newly established plots do not afford this protection.

New Method of Classifying Forest Area

For several years, efforts have been made to develop a method of area classification that adequately and efficiently describes forest stands. Small areas can be accurately classified from actual measurements, such as a complete tally of all trees on a 1/5-acre plot, but classification based on these small areas tends to exaggerate extreme conditions. For example, in terms of areas that landowners would consider planting or harvesting, the area of nonstocked land or large sawtimber stands tends to be overestimated.

Recent technique studies indicate that classification based on conditions over at least an acre will greatly reduce this tendency to exaggerate extreme conditions. Classification of an acre based on complete measurement, however, is too costly, and an ocular classification tends to be highly subjective and involves a high risk of error. A compromise solution to this difficulty, which makes use of a sample of conditions on the acre, is being tried out on the third Survey in Georgia. The procedure measures both area controlled and area distribution of the significant types of forest vegetation on the acre.

The method consists of recording the frequency of occurrence of trees and shrubs on 20 variable-size circular quadrats having a common center. These points are located 30 links apart on a 6-chain square traverse around the center of the acre. Quadrat size is determined by the number of well-spaced trees required to fully utilize the acre, which in turn varies with the size of the tree. In Georgia, the radius of the quadrat (limiting distance) in feet is equal to the d. b. h. of the tree in inches. This permits the use of an angle gage or wedge prism with a basal area factor of 75.625 to determine the occurrence of any size tree at a point. Where two or more trees fall within the limiting distance of the point, occurrence is assigned to the most dominant tree.

A summary of the number of points controlled by various types of vegetation provides the basis for estimating forest type, stand size, and stocking class. It also provides the basis for estimating current and prospective stocking of desirable trees and the type of forestry action required to increase stocking.

Recording recent changes in the tree or shrub cover controlling each point provides a measure of the effect of cutting, forestry practices, and damage from fire, insects, and disease on stocking.

Trial of Electronic Computers for Processing Forest Survey Data

Forest Survey data for northwestern Florida were processed using both the IBM 607 electronic calculator (the present method) and the IBM 650 electronic computer. Results of the comparative test were reported at a Forest Service conference at Atlanta in September.

Cost of the two methods was approximately the same, but each machine had certain merits to commend it. Advantages of the IBM 607 computer are:

1. It is a simpler machine to program and operate than the 650. Thus, the problem of training or hiring competent programmers is considerably less.
2. A Survey processing program based on the 607 computer is more flexible and more easily modified than one based on the 650.
3. Additional computations not originally anticipated can be handled quickly and economically.

Advantages of the IBM 650 computer are:

1. Time required to process the data for a Survey unit might be only one week as compared to at least a month using the 607.
2. Once a 650 program has been thoroughly checked, there is less chance of human error because it requires less card handling and fewer processing steps.
3. The 650 is more reliable than the 607 because of the automatic computational checks built into the machine. Undetected machine errors are virtually non-existent with the 650 but are encountered occasionally in 607 computations.
4. A 650 program can produce information in more usable form than the 607. The greater storage capacity of the 650 permits combining and punching out information in summarized form.
5. The 650 easily handles complex volume equations that cause difficulties when using the 607.

Increased Pulpmill Demand for Hardwoods and Wood Residues

Pulpwood production in the Southeast made a slight recovery during 1958 from the recession low of 1957, but remained 251,000 cords under the record level of 11,272,000 cords set in 1956 (table 12). The partial recovery was due entirely to increased utilization of hardwoods and wood residues, principally sawmill chips. Pine pulpwood production was at its lowest level since 1954, more than a million cords below the 1956 peak. Hardwoods, on the other hand, continue to show an increase each year. The 1958 production of 1,344,000 cords was 248,000 cords above 1956. Wood residues have nearly doubled every year since 1953, and the 1958 production of 732,000 cords was 279 percent above 1956.

The rapid growth of the pulp and paper industry, as measured by the level of pulpwood production, has suffered only one other setback since World War II. The recession of 1949 depressed the markets for both pine and hardwoods but both recovered the following year. In 1956, only pine production declined, and it fell an additional 422,000 cords in 1958.

Pulpwood prices in the Southeast remained stable at record levels. The 1958 survey of pulpwood prices revealed only slight changes from the previous year. Average pine prices remained unchanged at $15.50, in spite of the pronounced drop in production, while hardwood prices averaged $13.45, ten cents a cord higher. Chip prices were steady—$6.10 per ton at most mills.

Which Landowners Practice Forestry?

Why does one person practice forestry while his neighbors do not? The answer to this question is a key to what action would make the region's small woodlands produce more timber for industry and more income for owners. Data from interviews with 200 landowners were analyzed to see if the individuals most interested in forestry display any features that distinguish them from other owners (fig. 34). Of the 200, half believe that forestry is or could be profitable for them, but only a third actually practice it.

Individuals who practice forestry tend to have three characteristics in common. First,

Figure 34.—Interviews with 200 small forest landowners show that only a third of them are practicing forestry.

they have sold timber within the past 10 years. Second, they are the younger landowners. Third, their woodlands rank above average in both actual acreage and proportion of the entire property that is forested.

Among persons who sold timber during the past 10 years, one out of three is practicing forestry. This is in contrast to one out of four of those who did not sell. One reason why owners who recently sold timber may be more inclined to practice forestry is that by selling they realize they can earn income from their woodlands and so are more willing to invest in them. Another possible reason is that some of the people encountered in the course of making a timber sale may stimulate the owner's interest in forestry by showing him how returns from his woodland can be increased by practicing forestry.

Table 12.—Pulpwood production and prices in the Southeast, 1945-1958 [1]

Year	Pine roundwood		Hardwood roundwood		Wood residue	
	M cords	Dollars per cord	M cords	Dollars per cord	M cord equiv.	Dollars per ton
1945	3,806	8.45	525	8.10	--	--
1946	3,993	10.10	718	9.70	--	--
1947	4,171	10.95	665	9.80	--	--
1948	5,565	11.70	768	11.05	--	--
1949	4,942	11.00	594	10.80	--	--
1950	6,140	11.90	717	11.00	--	--
1951	6,916	13.85	826	12.75	--	--
1952	7,030	13.90	744	12.80	--	--
1953	7,990	13.90	806	12.75	28	--
1954	7,964	13.95	852	12.75	54	--
1955	9,076	14.35	1,006	13.05	112	--
1956	9,983	15.45	1,096	13.50	193	--
1957	9,367	15.50	1,190	13.35	427	6.10
1958	8,945	15.50	1,344	13.45	732	6.10

1/ Prices are weighted averages of all wood loaded on railroad cars, trucked to pulpwood yards, and delivered to pulpmills. They include dealers' allowances in cases where they are paid.

People who practice forestry are, on the average, about 20 years younger than those who do not. Young people tend to be more interested in forestry than old people, not only because they have a longer time in which to reap returns from forestry investments, but also because they are more likely to have been influenced by forestry educational programs.

The woodland area of owners who practice forestry is twice as large as that of those who do not, and it makes up a larger proportion of their total property—about 20 percent more. This suggests that an individual's interest in increasing the productivity of his woodland depends upon how important a part it is of his total assets.

The fact that people who practice forestry have common characteristics that distinguish them from those who do not indicates that possibly there are definite factors which motivate owners to practice forestry that can be uncovered. Such knowledge would be highly valuable in planning forestry programs.

FOREST FIRE

FIRE BEHAVIOR

The "Pungo 1959" Fire -- A Case Study

The Pungo 1959 fire burned April 8 to 11 in the low, swampy organic soil area of coastal North Carolina in Hyde and Tyrrell Counties, the scene of many disastrous fires in past years. The fire started on the afternoon of April 8 when a brush disposal burn spotted over a protective canal into a brush fuel that was about 4 feet tall and weighed about 8 tons per acre (fig. 35). The maximum rate of spread was about 1 mile per hour, and the fire ran uncontrolled until late that night when rising humidity stopped the head.

Conditions at 2:00 p.m. on the 8th were: burning index, 60; buildup index, 44; fuel indicator slats, 3.8 percent moisture; air temperature, 80° F.; relative humidity, 50 percent; and wind speed, 10 miles per hour. The ground water table was near the surface, precluding ground burning. Taken together, these measurements indicated very severe burning conditions. As a result, the surface litter, brush foliage, foliage on pond pines 5 to 6 feet high, and stems smaller than 3/16 inch in diameter were generally consumed—an estimated 56 percent of the total fuel.

Winds aloft profiles over stations surrounding the fire area could be considered borderline from the standpoint of extreme fire behavior. The absence of clear-cut adverse wind profiles, the high water table, and rather low fuel volumes, probably explain why the fire did not exhibit extreme behavior.

The next day, April 9, the fire broke out again near its origin and by 1:30 p.m. a very high intensity head had developed (fig. 36) which made a run for the day of about 11 miles and burned perhaps 10,000 acres, most of it between the hours of 1:00 p.m. to 4:00 p.m. The estimated rate of spread was over 2 miles per hour during this period. At its peak intensity, the fire had "blowup" characteristics except for long distance spotting and whirlwinds. These may have occurred but were not reported, possibly because men were not near enough to the fire front to observe them. Spotting up to 400 feet ahead of the fire was observed about 3:00 p.m.

There was extremely strong convective activity over the fire; the smoke column, which had a white water-vapor cap, boiled up to a height of 10,000 feet. Measurements from timelapse camera photos indicated that updraft velocities in the top of the convection column reached 25 miles per hour. Velocities within the center of the column could not be measured but may have been twice as great.

Figure 35.—Gallberry and fetterbush brush type burned on April 8 by the Pungo 1959 fire. Fifty-six percent of the 8 tons per acre of total fuel was consumed. Unburned fuel is in the background.

Figure 36.—Convection column at 2:50 p. m. on April 9 during the blowup period. Fuel weighed 14 tons per acre, and 9½ tons per acre were consumed.

Timelapse photography techniques permitted study of several other fire behavior characteristics not normally discernible. For example, the characteristic outward and downward rolls on the flanks of the growing smoke plume were plainly visible.

During the period of greatest intensity the fire burned in three different fuel types, ranging from a loblolly bay-fetterbush brush type weighing 9½ tons per acre to a very tall cane-tall gallberry type weighing 15 tons per acre (fig. 37). Fuel consumption ranged from 64 to 93 percent of total weight with the heaviest fuels burning most completely (fig. 38). In all types, brush foliage and stems smaller than 3/16 inch in diameter were consumed: cane was consumed completely. Pond pine foliage was consumed to a height of 10 feet and the rest scorched.

The 2:00 p.m. fire danger station readings were: burning index, 65; buildup index, 50; fuel indicator slats, 5 percent moisture; air temperature, about 83° F.; relative humidity, 67 percent; and wind speed, about 20 miles per hour. Winds aloft profiles over Cherry Point and Norfolk, two stations located in or near the air stream passing over the fire area, were conducive to extreme fire behavior (fig. 39).

Progressively smaller runs occurred on April 10 and 11, but by this time fire weather had moderated and effective suppression action brought the fire under control. From a fire behavior research standpoint, the runs of April 8 and 9 are of most interest in that the fires were free burning and unaffected by suppression action.

Figure 37.—Very tall cane-tall gallberry brush type (about 7 feet tall) before the fire contained 15 tons per acre of understory vegetation and litter.

Figure 38.—Very tall cane-tall gallberry brush type after the big run on April 9. About 14 tons of the total 15 tons per acre of fuel were consumed, not counting crowns of the overstory pond pines.

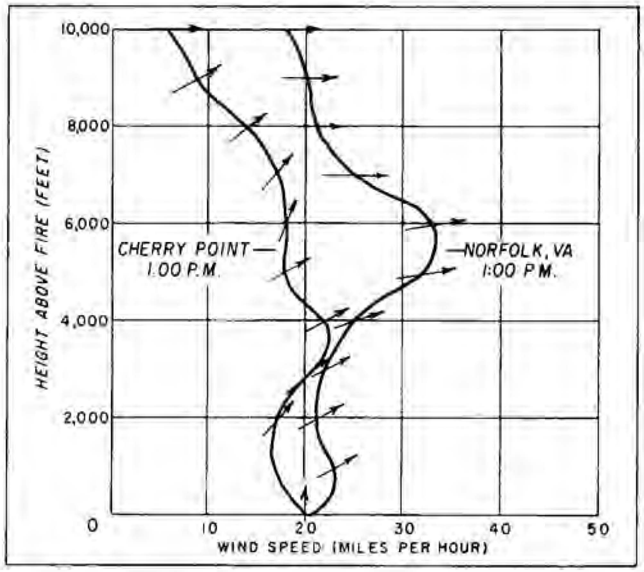


Figure 39.—Wind speed and direction above two stations in the wind stream over the fire area on April 9, 1959. Both profiles were classified adverse, based on the "Key-Vertical Wind Profiles and Associated Fire Behavior in Flat Country." Note that the wind at 10,000 feet is blowing clockwise to the surface wind. The convection column changed direction accordingly.

Ember-Lifting Power of Convection Column Updrafts

Advances in fire behavior knowledge in the last few years have reduced considerably the element of mystery which in the past has been associated with high-intensity fires. The Division's work in fire behavior has been based primarily on an energy approach and much of the effort has been directed toward describing fire behavior in quantitative terms. This work, some of which was described in the Station's annual report for last year, could be designated more briefly as the task of "putting numbers" on fire behavior.

The quantitative description of fire behavior has ranged from relatively simple problems, such as defining fire intensity in terms of rate of energy output, to more complex problems, such as the study of energy conversion processes in the convection column and the development of scaling laws for work in fire modeling.

How the development of a specific quantitative relationship can remove some of the mystery of fire behavior is illustrated by an analysis of one phase of the spotting process: namely, the relationship between fire intensity and the ember-lifting power of the updrafts over a fire. This relationship can be expressed in dimensionless form by the equation $W/W_0 = (I/I_0)^2(D/D_0)^2$ in which W_0 is the weight and D_0 the density of an ember which will just be supported in an updraft over a fire with a reference intensity of I_0. The weight W and density D apply to an ember which will be supported by the updrafts over a fire of any given intensity I. The quantities W_0 and W could also be regarded as the weights of the model and full scale embers respectively.

The equation expresses an important relationship. It shows that the weight of an ember which can be carried aloft by the updrafts over a fire is directly proportional to the square of the fire intensity. For example, a three-fold increase in fire intensity should correspond to nine-fold increase in ember weight which the updrafts can support. This may explain in part why the meeting of a head fire and backfire can sometimes result in extensive spotting. A similar phenomenon can occur when a fire burns into heavy fuel. The equation also shows that the weight of an ember which can be carried aloft is inversely proportional to the square of the ember density. Thus embers of low density, such as decayed wood, or punk, would be carried aloft more readily than embers of denser substance but of equal weight.

The derivation of the equation is based on the assumption that the drag force acting on a falling ember is directly proportional to the square of the speed of the ember relative to the environmental air. This assumption requires that the dimensionless drag coefficient for an ember of any given shape be approximately constant throughout a wide range of Reynolds' numbers. This approximation is very good for a wake-producing object, such as a flat plate with its surface perpendicular to the direction of flow, but is not so good for

a smooth object with a more streamlined shape. However, the approximation may be good for most ember material but this will have to be determined by experimental tests.

Dimensional relationships given by the equation of motion for an object falling in a resisting medium indicate that the drag coefficients for different kinds of embers can be determined by relatively simple free-fall tests from heights which may not have to exceed 100 feet. These tests will also give for different embers the Reynolds' numbers corresponding to their terminal velocities. Depending on the size, shape, and density of the ember, the Reynolds' number in most cases will likely fall somewhere in the range from 2×10^3 to 6×10^5.

One Year's Experience with the Winds Aloft Monitoring System

Based on reports from the North Carolina Division of Forestry, experience with the winds aloft monitoring station at New Bern, North Carolina, has been decidedly favorable.

In the high-hazard organic soil area of coastal North Carolina, soundings of wind speed and direction aloft have been taken since the fall of 1958 during periods when fire danger was progressively increasing. Interpretation of soundings in terms of the potential for extreme fire behavior was made, using the interim report, "Key-Vertical Wind Profiles and Extreme Fire Behavior," prepared by the Division. Expected fire behavior is considered in suppression activities on going fires or used in presuppression planning according to procedures established by the state.

Whenever a profile is adverse, that is, conducive to extreme fire behavior, a special warning is issued by the district dispatcher in New Bern to suppression units in his and other districts and to cooperators. Units with small going fires increase their control efforts in an attempt to keep the fires below the size at which a blowup might occur.

On large fires the warning is used as a basis for adjusting deployment of control forces to make them more effective and as an alert for possible evacuation in case a blowup occurs. When the direction aloft differs from that of the surface winds, air and ground patrols are instructed to be especially watchful for spotting in the direction of the wind at the upper levels. On numerous occasions, suppression forces noted symptoms of unusual fire behavior before control was achieved on days with adverse wind profiles and high fire danger.

During the 16,000-acre Pungo 1959 fire in April, the start of the blowup period and main run were observed to coincide with the onset of an adverse profile. The fire boss reported that the warning provided by upper air soundings was extremely valuable in understanding the behavior of the fire and in planning successful suppression action.

As a result of favorable first-year experience with the system at New Bern, a second station has been established at Whiteville, 100 miles to the south. Data from the two stations will be compared to study the areal extent of a given wind profile.

FOREST FUELS

Classification of Forest Fuels in Terms of Total Fuel Energy

Classification of the principal forest fuel types in the organic soil area of coastal North Carolina in terms of total fuel weight (directly convertible to total fuel energy) was completed in 1959. Three additional types, wiregrass, high pocosin, and very high cane (figures 40, 41, and 42), were added to the eleven sampled previously on Hofmann Forest. Together they represent the range of fuel types and fuel weights to be found in the organic soil areas of North Carolina.

The tentative classification system is summarized below:

Total fuel weight class (Tons/acre)	*Fuel type*	*Total fuel weight* (Tons/acre)
4.1-5.7	Wiregrass	4.46
5.8-8.0	Low Brush Open	5.90
	Low Brush-Cane Open	6.42
	Low Brush-Grass	6.54
8.1-11.0	Low Brush Dense	8.25
	Low Cane	8.80
	High Cane	9.78
	Medium Brush	8.58
	Low Brush (Sand Ridge)	9.18
	Low Brush	8.46
11.1-16.0	High Pocosin	15.00
	Very High Cane	12.83
16.1-23.0	High Brush	17.47
	High Brush (Swamp)	18.86

In the tabulation each succeeding class has significantly greater potential for extreme fire behavior. Using available laboratory facilities, calorimeter tests will be made to determine the heat content of the different fuels. The unit of measurement then will be Btu's rather than tons.

Guidelines for identifying and mapping the fuel types in the field are being developed.

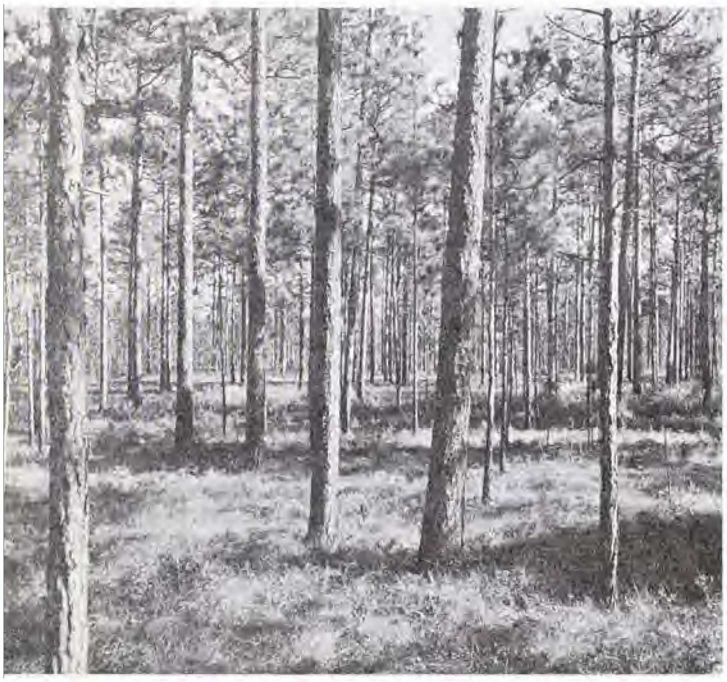


Figure 40.—Wiregrass fuel type. The understory vegetation and litter weighs about 4½ tons per acre. The overstory is pond pine.

Figure 41.—High pocosin fuel type. Composed of gallberry, redbay, cane, and greenbrier, this type contains 15 tons per acre of understory vegetation and litter. The overstory is pond pine.

Figure 42.—Very high cane fuel type. This type contains 13 tons per acre of understory vegetation and litter. The overstory is pond pine.

Moisture Regime of Understory Vegetation in Coastal North Carolina

The moisture content of forest fuels, including the litter and dead and green standing vegetation, exerts a strong influence on fire behavior. In general, fire intensity and rate of spread are inversely proportional to fuel moisture content The moisture content of dead forest fuels is known to fluctuate with the weather but the moisture regime of living vegetation is less well known.

Understory vegetation is a major component of forest fuels on the organic soils in coastal North Carolina. As part of a comprehensive study of fuels in this fire problem area, moisture content determinations of whole plants of gallberry (*Ilex glabra*), redbay (*Persea borbonia*), swamp cyrilla (*Cyrilla racemiflora*), and switch cane (*Arundinaria tecta*) were made for nearly one year in 1959. Figure 43 indicates that moisture content can vary widely by season and among species. The largest differences occurred during the spring and fall. During these seasons, cyrilla had the greatest change, 45 percent. Of the other species, redbay had a range of 35 percent, gallberry 25 percent, and switch cane 20 percent. In the spring the moisture content of all species except gallberry started to increase about April 1, rising fairly rapidly to a maximum about May 15 for cane and July 1 for the other species. The increase for gallberry began six weeks later. A gradual decrease in the moisture content of cane began about June 1 and, for the other species, July 15.

The moisture contents of foliage and stem components followed the same general seasonal regime as the whole plant except that moisture maximums and seasonal changes for foliage of all species were much greater than for whole plants. Cyrilla foliage, for example, varied from 195 percent moisture content in the spring to 120 percent in the witner, a difference of 75 percent. Stems seldom fluctuated more than 20 percent in moisture con-

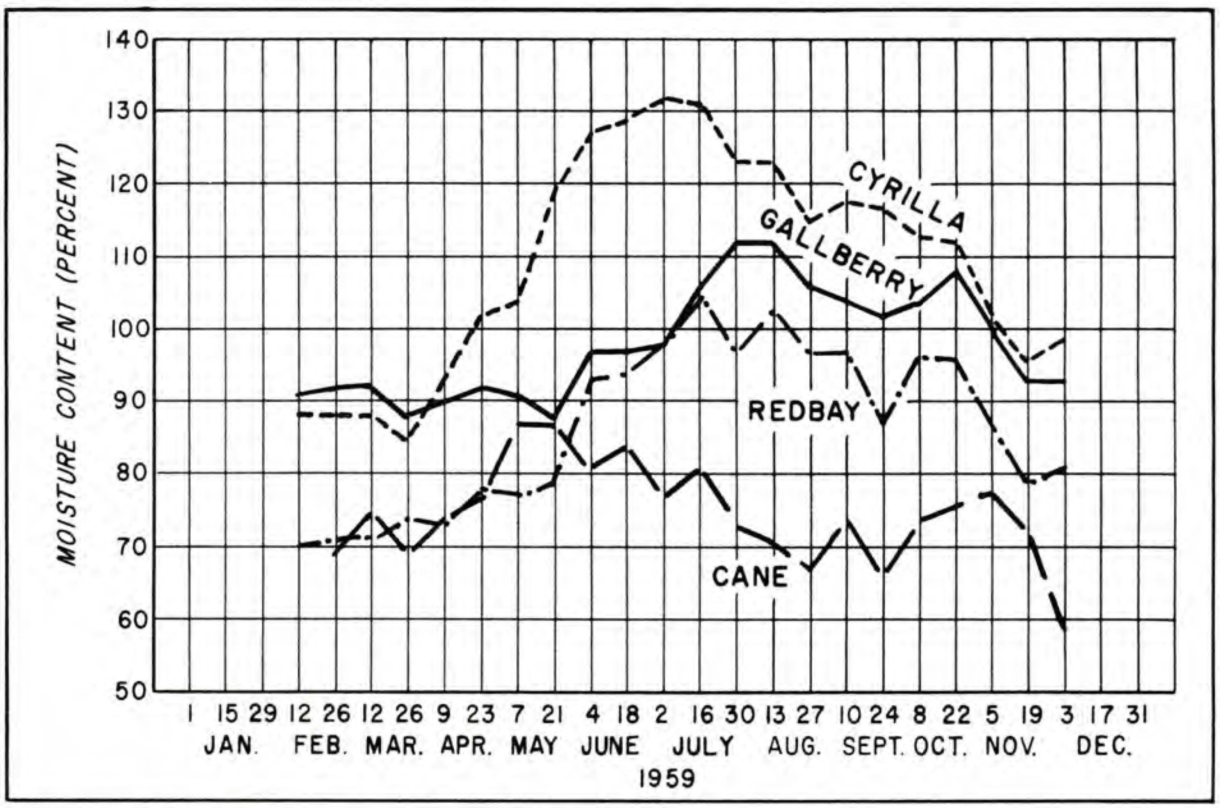


Figure 43.—Whole plant moisture content of common species of understory vegetation on the organic soils of coastal North Carolina.

tent or contained more than 100 percent moisture.

Whether similar differences between seasons and among species will be found in other years is not known. Neither do we know the effect of high or low soil moisture on plant moisture.

Estimating Fuel Weight of Pond Pine Crowns

In a study of fuel classification on organic soils it was desirable to find some rapid means of estimating the contribution of the overstory pond pine crowns to total fuel weight, because tree crowns are not readily accessible for sampling from the ground. In blowup fires even the crowns of tall trees will burn and contribute significantly to total energy released.

The curve in figure 44 may be used to estimate the weight of foliage for pond pine on the organic soils of North Carolina. Correlation was improved slightly when diameter at breast height inside bark was substituted as the independent variable; however, dimensions of the stem inside bark are difficult to estimate or measure.

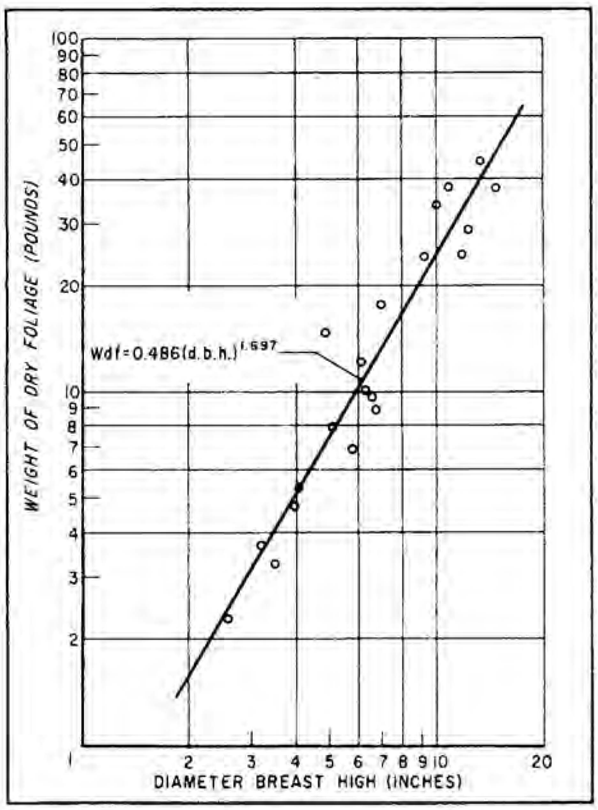


Figure 44.—Relation between the ovendry weight of pond pine foliage and d. b. h.

Because pond pine generally grows in even-aged stands, the contribution of the foliage to total fuel weight can be estimated by determining the average diameter of a particular stand and multiplying the total number of trees by the values read from the estimating curves. For example, a pine overstory averaging 100 trees per acre and 10 inches d. b. h. would contribute 2,400 pounds of foliage to total fuel weight per acre. If the understory vegetation and litter weighed 8 tons per acre —about average for pocosin fuels—the addition of foliage would increase this weight about 16 percent to 9-1/5 tons.

FIRE DANGER MEASUREMENT

Studies of Fuel Moisture Indicator Sticks

Estimated fuel moisture content is a major element in fire danger rating; it is common to all rating systems, although expressed in different ways. All but two regions in the United States use either thin basswood slats or ½-inch pine dowels to reflect the moisture content of lightweight fuels. Some systems require screens over the indicator sticks to simulate a degree of forest canopy shade, others do not. Two regions measure the key weather variables that control fuel moisture and enter this information directly into their fire danger meter.

In the interest of exploring a standard method for estimating fuel moisture for the national meter, a study of fuels and fuel moisture was begun this year at the Southern Forest Fire Laboratory (figures 45 and 46). Current investigations include the measurement of slat and dowel moisture contents to determine the relative response of slats and dowels, the effect of different degrees of screen shading, and whether stick moisture content can be estimated from weather variables with acceptable accuracy.

A number of basic differences have been noted between slats and dowels. The surface temperature of slats is consistently higher than dowels under the same amount of shading; differences are greatest on clear days and least on cloudy days when both surface

Figure 45.—Fuel moisture stick study installation at the Southern Forest Fire Laboratory showing replicated screen shade frames and weather instrument locations. Racks for preweathering slats are in the background and an open-type danger station is in the right foreground.

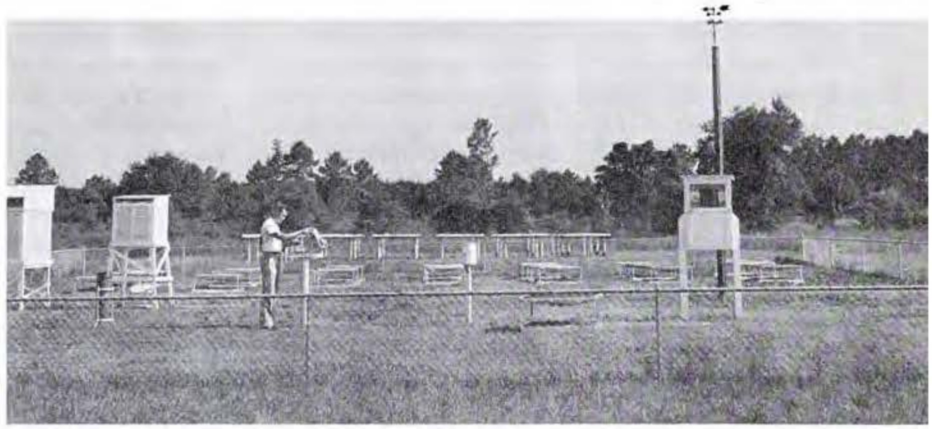


Figure 46.—Test sets of basswood slats and pine dowels under no screens. Other test sets are exposed under 1, 3, 4, and 6 screens.

temperatures approach air temperature. Slat temperatures as high as 127° F. and corresponding dowel temperatures of 116½° F. were measured in the open on clear days when the air temperature was 100° F. The higher temperatures probably result from the difference in geometry and color and associated radiation effects.

For similar reasons, the moisture content of slats invariably is lower than dowels for equal shading; differences are greatest on clear days and the two moisture values approach each other on cloudy days. Slat moistures as low as 2½ percent and dowel moistures of 7 percent were recorded in the open on clear days when the air temperature was 100° F. Dowels respond much more slowly than slats to weather changes, frequently lagging behind slats as much as 10 hours or more.

Both slat and dowel surface temperatures decrease rapidly as screen shading is increased. Temperature differences of 7° F. between 0- and 1-screen and 20° F. between 0- and 6-screens for both slats and dowels are not unusual On this basis we would expect the moisture contents of both slats and dowels to increase with increasing shading and slats to increase the most. Thus, the moisture content of slats under 6 screens may be higher by 1¾ percent compared to slats under 1 screen. Dowel moistures average 1¼ percent higher under 6 screens compared to 1 screen.

The relation between the moisture content of indicator sticks and that of actual surface fuels will be studied under controlled conditions at the Southern Forest Fire Laboratory. Fuel moisture conditions under the various degrees of shading provided by screens will be equated to actual forest conditions by comparing light transmittance under screens and forest canopies.

Bronze vs. Aluminum Screens for Shading Fuel Moisture Slats

The effect of aluminum and bronze screening materials on the moisture content of basswood indicator slats at open-type fire danger stations is being investigated at the Southern Forest Fire Laboratory.

Although our instructions for operating danger stations recommend bronze screens, aluminum screens are widely used because of ready availability and lower cost. Because aluminum remains bright, we thought that slats under screens made of this material might possibly react differently. Analysis of slat moistures under 6 layers of aluminum and 6 layers of bronze screen tested this summer indicated that the differences were statistically significant, but the cumulative differences were so small that almost no effect on buildup and burning index was noted. Some compensating effects are suspected because of the wide differences in reflectivity and absorptivity of the two materials, particularly for long wave back radiation. No definite conclusions can be reached until a full year's data have been analyzed.

Progress in Developing a Unified Fire Danger System

A 1958 joint committee of fire research and fire control men, meeting in Washington, considered the reasons for attempting the development of a unified fire danger measuring system. The committee explored possible approaches and suggested a development program. Following the committee recommendation, a staff position was created in the Washington Office Division of Forest Fire Research, and John Keetch was assigned to the project with field headquarters in Asheville, North Carolina. Work got under way in the fall of 1958.

By mid-1959 a field survey of the needs and uses of fire danger data was completed for each region, including an on-the-ground study of all the fire danger systems in current use. The study verified that all fire danger systems are based on weather influences, but that there are large differences which stem from lack of a common basis for interpreting weather changes. To meet field needs a national system must be flexible enough to serve organizations requiring only a general guide, or a single index, as well as those who regularly use fire danger data in many ways, from timing and evaluating fire prevention effort to initial attack planning on specific fires.

In developing the national system attention was focused on the problem of establishing servicewide fuel standards. Since regional fuels commonly range from thin grass blades in the open to large logs under the forest canopy, the separation of this tremendous response-range into meaningful segments is no simple task. Preliminary research indicates that it should be possible to identify fuels that

belong to a particular drying regime in terms of their relative drying rates, providing a standard drying potential (weather) is maintained. A suggested standard for identifying surface fuels and an outline of the research needed to test the standard and to develop a method of measurement was completed by midsummer.

At a meeting of the fire danger advisory committee it was agreed that an attempt should be made to complete the framework of a trial system by the summer of 1961 to be followed by a 2-year testing program, with the objective of having the unified system ready for field use by 1963. It will not be possible to complete all of the needed research within the time schedule. Thus, the committee urged that a preliminary national system should be designed insofar as possible with sufficient flexibility so that improved relationships can be added as they become established through additional research.

PRESCRIBED BURNING STUDIES

Periodic winter backfires in the coastal plains of the Southeast reduce fuel accumulations considerably, but the reductions, particularly in the weight of live vegetation, are rather short-lived. Litter weights on the Osceola National Forest in Florida one year after prescribed fires in roughs at least 5 years old were about 42 percent of their original weight. On the Francis Marion National Forest in South Carolina in similar-aged roughs, litter weights were about 55 percent of their original weight one year after burning. Vegetative accumulations (gallberry-myrtle-bay fuel type) on the Francis Marion had built up to their original weight within one year after burning, even though plant heights remained at a lower level. On the Osceola (palmetto-gallberry fuel type), vegetative buildup of this proportion required a 2-year period.

Temporary reduction of fuel accumulations by periodic winter backfiring may play an important part in keeping the number of large fires to a minimum. Fires are difficult to start in stands where litter is sparse and they seldom reach high intensities where vegetation is light or lacking.

On a study area of about one million acres in south Georgia and north Florida, the effect of age of rough on the nature and frequency of wildfire occurrence was investigated. Data were collected from 374 fires on 954,000 acres for 4 years, 1955-58, a span which included two bad fire years, one easy year, and a moderate year (fig. 47). Although a higher occurrence rate was indicated for the roughs 3 years and older, the differences were not extreme.

On the other hand, the differences in burn acreage, particularly between the youngest and oldest roughs, were extreme. Twelve fires of over 200 acres occurred on the study area during the 4 years considered and all of them originated and burned in the older roughs.

The effect of repeat fires of varying intensities on fuel reduction is being studied on the Waycross State Forest in south Georgia. Following a normal winter prescribed backfire, successful summer and fall burns were achieved by strip firing techniques where litter weights averaged at least 3 tons per acre (fig. 48), fuel moisture content ranged from 6 to 14 percent, and variable winds averaged 2 to 5 miles per hour. Litter accumulations of less than 3 tons per acre failed to carry any type of operational fire under the weather conditions encountered.

When fuel accumulations were heavy, as for example in the initial winter burns in 15-year-old palmetto and gallberry roughs, head fires (in strips) and backfires reduced litter weights about 60 percent. When fuel accumulations were light, as found in repeat burning, and the same range of weather conditions prevailed, backfire burning was unsuccessful.

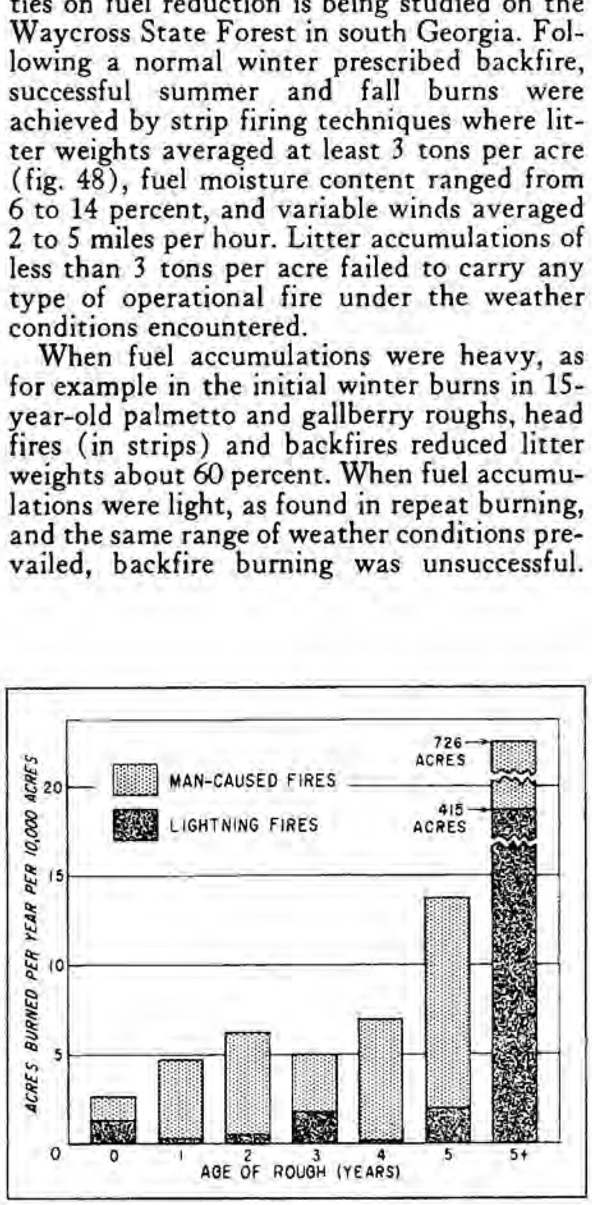


Figure 47.—Average annual number of wildfires.

Figure 48.—Litter is collected from sampling units to determine the weights of available dead fuel.

Strip fires, however, performed satisfactorily, and consumed another 55 percent of the remaining litter. The effect of repeat burning on vegetation will be determined following the spring burns.

In 8-year-old palmetto and gallberry roughs of the coastal plains, heat peaks of 1600° and 600° F. were obtained for summer head fires and backfires, respectively (fig. 49). In typical Piedmont fuel types on the Hitchiti Experimental Forest that had been free of fire for at least 10 years, heat peaks of 1000° and 500° F. were obtained. The Btu outputs from head fires and backfires in the same fuel were essentially equal, even though the backfires required at least twice as much time to reach their potential.

Moisture Content of Aerial Fuels

Samples of palmetto, gallberry, wiregrass, and slash pine needles were collected biweekly from a timbered area in the lower coastal plains of Georgia to detect possible moisture content fluctuations and the probable causes.

Preliminary findings show the presence of fluctuations but fail to tie them in directly with any of the measured weather elements. Rather, physiological processes within the plants appear to be responsible for the variations. During the 6-month period from July to December, the highest moisture contents for all samples were measured in July, followed by fluctuating declines in August and a very stable period from September to December. Moisture content of pine needles, averaging about 175 percent of ovendry weight, remained consistently higher than other material; the moisture content of wiregrass, averaging about 50 percent of ovendry weight, was lower than other material.

The higher moisture contents and the greatest fluctuations in moisture content were measured in the foliage of the plants under observation, with the exception of palmetto. Palmetto fronds exhibited greater fluctuations than the stems, but contained less water.

AERIAL FIRE RETARDANTS

Monoammonium phosphate solutions, dropped from a TBM aerial tanker for the first time in 1959, appear to be the most effective aerially delivered fire retardants in use at the present time on coastal plains vegetation in the South. Fast-moving head fires in heavy fuels were stopped along lines at least 175 feet long as a result of 220-gallon aerial drops (figures 50 and 51). A fertilizer containing 12 percent nitrogen and 61 percent P_2O_5, the material is not toxic to plant life and goes into solution with water readily. When compared with other retardant mix-

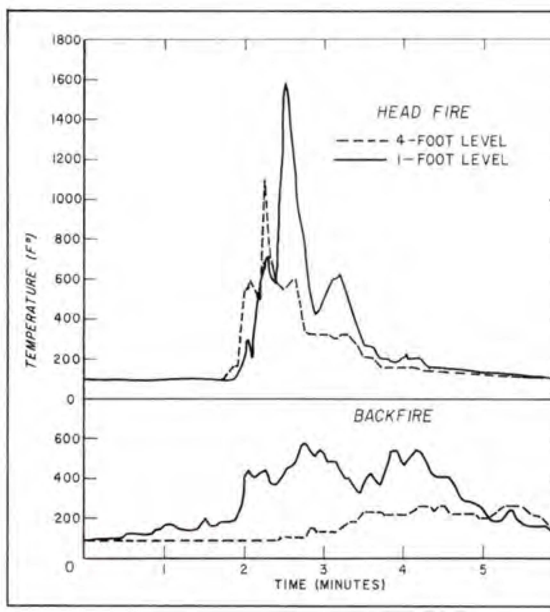


Figure 49. — Time-temperature recordings for head fires and backfires in 8-year-old palmetto and gallberry roughs.

tures, it is relatively light in weight—9.1 pounds per gallon at 15 percent concentration.

The application rate needed to stop a fire was estimated to be about 1 gallon per 100 square feet of ground area. This protection was effective until the material was washed from the vegetation by rain or heavy dew.

Further tests with sodium calcium borate, another good fire retardant, indicate that borate slurry is toxic to some southern vegetation. Loblolly pine and sweetgum seed failed to germinate when the germinating media were treated with borate applications of 3 and 6 gallons per 100 square feet. When borate is applied extensively at application rates of at least 3 gallons per 100 square feet over a tree's root area, mortality may be expected in all tree sizes (fig. 52). Weak application rates on a limited soil area or restricted to the foliage are usually not fatal to trees, although dieback or growth loss may occur.

Further calibration of the TBM aerial tanker showed that approximately 80 percent of the slurry was accounted for when dropped in 220-gallon or 440-gallon loads in an open area from an altitude of 85 to 100 feet at a plane speed of 110 knots. The remaining 20

Figure 50.—Fast-moving head fires in heavy fuels were used to test the effectiveness of different fire retardants.

percent was probably lost as evaporation or dissipated as fine mist. Total drop lenth, where the dropped material fell in measurable quantities, extended 400 feet or more. However, that part of the pattern length with application rates of at least 1 gallon per 100 square feet seldom exceeded 250 feet in length. The 1-gallon zone conforms closely to the effective length of fireline made by a 220-gallon drop.

Drops through a 20-year-old pine stand with a 60 to 70 percent crown closure showed that the crowns themselves will intercept about 30 percent of the material. As a result, larger drop loads are required in timbered areas than in the open. In relatively open areas (poor tree stocking), 200- to 300-gallon drops of effective retardant material will stop most fast-moving surface fires along a 200-foot front. On the other hand, where tree stocking is heavy and tree canopies intercept considerable material, drops of at least 400 gallons are necessary to get the same effective 200-foot fireline.

Figure 51.—Test fires were stopped by monoammonium phosphate.

Figure 52.—Longleaf pine trees in the center of a drop area may be killed as a result of heavy borate applications.

MISCELLANEOUS

Our Southern Forest Fire Laboratory at the Forestry Center near Macon was formally opened by Governor Ernest Vandiver on November 4.

As a result of the Division's suggestion at the conference held in Washington to discuss Form 929 fire report revision, a supplemental form is being devised on which fire behavior information will be recorded for fires 300 acres or larger.

Several members of the Division attended an international symposium on fire modeling in Washington in November. The conference was sponsored by the Committee on Fire Research of the National Academy of Sciences, National Research Council.

A comprehensive study of fire danger rating and its applications in Georgia is under way. Forty key stations have been selected and are being checked periodically by members of the Division. The first year's records of danger and fires are ready for analysis.

Two additional sites have been selected and crews trained in operating pilot balloon installations. They will be located in the coastal plain of North Carolina and Georgia and will be operated by state personnel. The purpose is to detect low-level jet activity that has frequently been found associated with severe fire behavior.

Detailed fire-weather forecasts for the State of Georgia were prepared routinely again this year by the U. S. Weather Bureau Meteorologist assigned to the Laboratory. Studies are planned on forecasting very low humidities and determining the most persistent wind directions for prescribed burning.

H. E. Adams has been assigned by Region 7 to replace J. J. Keetch. He is stationed in Asheville and is responsible for assisting states and national forests in the operational aspects of danger measurements and their application.

Two far reaching developments mark the 1959 utilization picture. One is the greatly expanded use of hardwoods for pulp, both in round wood and chips. The second is the development of sparse tooth saws that permit the use of saw chips (coarse sawdust) for pulp. These developments are new-born, so to speak, but should grow to be important facets of the wood utilization field in the years to come. Their fruition is the result of efforts of many scientists and industry people, working together towards a common goal.

Outside Storage of Pine Pulpwood Chips

Many pulp companies in the South buy pulpwood in the form of chips from sawmills and other wood-using industries. Perhaps the most economical way to store these chips is in outside piles. Pulp companies in the West have been storing chips in the open for periods up to 4 years with practically no loss from deterioration. In the warmer and more humid climate of the South, however, it is possible that serious deterioration of chips stored in the open may occur in a relatively short time.

The Station entered into a cooperative agreement with St. Regis Paper Company in the spring of 1959 to develop information on open storage of pulpwood chips at their Fargo, Georgia, yard.

It was agreed that the determination of factors causing deterioration and volume losses would be reported by the Forest Products Laboratory and the results of pulp quality tests by the Technical Department of St. Regis Paper Company.

A pile of freshly cut chips approximately 70 feet long, 40 feet wide, and 8 feet high was built on a 50 x 100-foot asphalt apron by a dump truck and D-2 Caterpillar tractor with blade (fig. 53). The action of the tractor over the pile served to compact the chips.

Samples were collected randomly as the pile was constructed and at 20 predetermined points in the pile profile 2 weeks later, and again in 1, 2, 3, 4, and 5 months. Green and air-dried chips from each sample were sent to the Laboratory for analysis, other green chips were weighed and ovendried for moisture content determination at Macon, and still others were sent to St. Regis at Pensacola for pulping tests.

A new pile profile was formed at each sampling by removing both the chips forming the angle of repose at one end and a 4-foot cross section of the pile. After samples were collected, surplus chips were pushed back over the front of the pile to reform the angle of repose (fig. 54).

Thermocouples were placed at 12 locations throughout a cross section of the pile that was to be torn down last so that temperatures within the pile could be plotted over the storage period. Temperature readings were taken daily when possible.

Weather data were collected from a recording hygrothermograph located near the pile, from a rain gage at a nearby fire tower, and from a recording anemometer placed on top of the pile.

Moisture content (ovendry basis).—The initial moisture content of the chips in the pile ranged from 91 to 116 percent. The moisture content of the surface layer increased to 140 percent as early rains wet the pile. The moisture content of the pile from surface to innermost sections gradually increased and at the end of 4 months the pile was fairly uniform with an average moisture content of 130 percent.

Temperature.—Almost immediately after the pile was erected, temperatures began to rise. After one week, the average temperature of the outer 2-foot layer of chips was just below 100° F. After 2 weeks, temperatures reached 131° F. 2 feet beneath the surface. For the duration of the study, the majority of the chips, excluding those in the side layers, did not fall below 90° F.

Stain.—In the last profile uncovered 146 days after the pile was built, the only heavily stained areas were those where temperatures fell below 90° F. Areas free from stain coincided very closely with the zone of temperatures above 90° F. (fig. 55). Temperatures may have been high enough for a sustained period to prevent the growth of blue stain fungi.

Figure 53.—Fifty-nine dump truckloads of chips were used to build the pile.

Figure 54.—Final pile dimensions were roughly 70x40x8 feet. Angle of repose is indicated by white line.

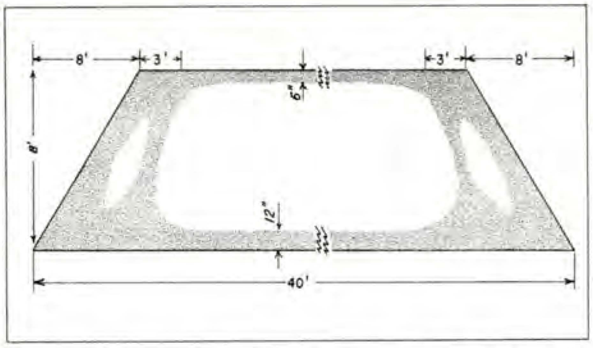


Figure 55. — Chip storage study pile after 5 months of open storage. The shaded areas indicate the location of prominent staining.

Specific gravity.—The periodic loss of specific gravity is shown in table 13.

Winter data are now being obtained from a second pile built on the same ramp in November 1959.

In summary, the most significant trend revealed by the moisture data is the progressive increase in moisture content with longer storage periods. Softness and brashness of dark stained wood were first evident in a few samples stored 13 weeks, and became increasingly common with longer storage periods. The appraisal of typical decay in the chips was complicated by the prevalence of dark stain.

Only minor reductions in specific gravity were shown for storage periods up to 8 weeks, and fungus infections apparently were not the primary cause of such reductions. For storage periods of 13 and 21 weeks, average specific gravities were 96 and 93 percent, respectively, of the average for green chips.

Table 13.—Condition of chips at sampling intervals

Time in storage	Specific gravity 1/		Average moisture content	
	Green	Air dry	Field measurement	FPL measurement
			- - Percent - -	
Initial	0.510	0.506	101	98
2 weeks	.505	.508	95	96
4 weeks	.498	.506	88	95
8 weeks	.492	.501	119	120
13 weeks	.484	.493	128	131
17 weeks	.479	.486	133	135
21 weeks	.467	.476	115	147

1/ Based on volume and weight when ovendry.

Methods of Sawing Pine for Grade

There are several accepted methods of sawing pine logs for grade. This study was designed to evaluate these methods by theoretically resawing selected logs and determining grade-yield by three methods of orienting visible knot defects on the cutting faces, and by four ways of turning the log.

A technique was developed using photographs of each board live-sawn from the study log (fig. 56), and a full scale end section diagram showing all the knot defects as they radiate from the pith. With these two planes available, plastic overlays containing theoretical saw cuts can then be placed over the end section and the boards imaginarily produced in this manner can be graded according to SPIB grading rules. The overlays may be turned to change the position of knots on the sawing faces. The boards can then theoretically be cut in the new position, graded, and total log values compared with values obtained by other defect orientation methods.

The three defect orientations under study are centering visible defects, cornering visible defects, and cutting the clear face of the log first. The four turning techniques are: (1) cut faces 1, 2, 3, and 4 in that order; (2) cut faces 1 and 3 and live saw the cant; (3) cut faces 1, 2, and 3; and (4) live saw the log. Data are obtained on the number of cuts removed from each face before turning the log to the next cutting face. These data are compared by each variable mentioned and log values are determined.

Twenty-three logs have been cut and are in various stages of processing. Comparative data obtained for two logs will serve as an example. The quality indices in the "Interim Log Grades for Southern Pine" were used with a base price of $78 per M board feet for No. 2 common lumber. Both logs were No. 2 grade and were 13.5 inches and 16.5 inches d. i. b., small end. The various sawing techniques tested by theoretically resawing the same logs produced lumber ranging from $108 to $135 per M board feet for the small log and from $133 to $168 per M board feet for the large log. In this case the spread was from $108 to $168 per M board feet for the same grade logs.

The number of boards removed from the sawing face before turning the log can produce a significant spread in lumber values. For example, the 16.5-inch log sawn clear face first and turned to cutting faces 2-3-4, in that

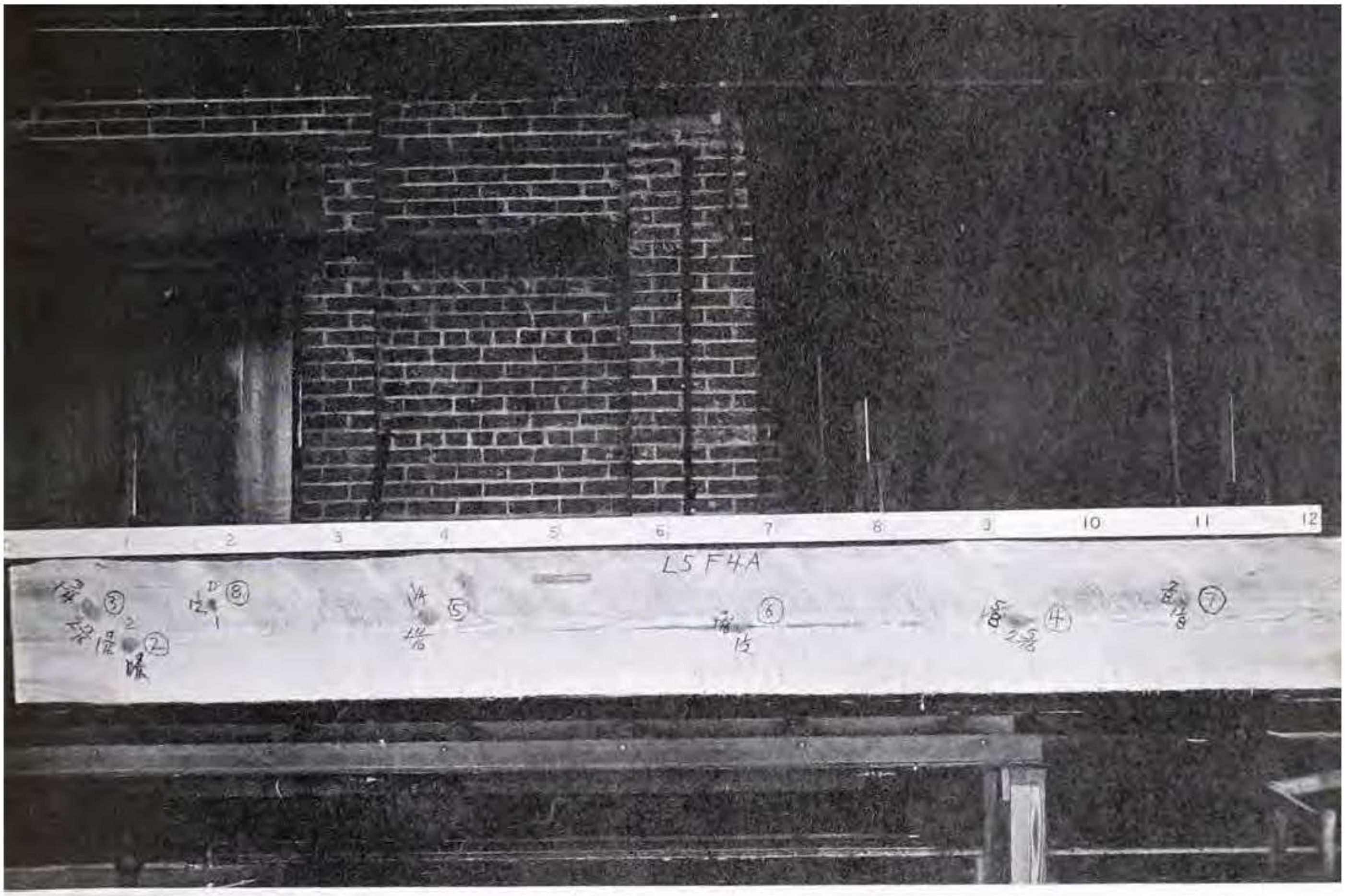


Figure 56.—Method of marking and then photographing defects on each board as the log is live sawn.

order, produced lumber valued at $158 per M board feet when 6 cuts were removed from the first face and 3 cuts from the second, and the remainder from faces 3 and 4. If only 2 cuts were taken on the clear face and 5 cuts on face 2, the value of the lumber would be only $145 per M. Any other combination of boards removed from the clear face would produce lumber between these two values.

The sequence of sawing the log faces also produces a variety of lumber values. The 16.5-inch log was theoretically resawed 56 times by keeping a constant of "cornering visible defects," but using 4 turning techniques. The remaining variables relate to the number of boards cut from each face before turning for each of the turning techniques. The lumber values ranged from $152 per M board feet to $168, provided the optimum method of removing boards from each face for each turning technique is used. The poorest method of removing boards per face for the same turning techniques produced lumber valued from $132 to $144 per M.

Quality of Pulp Chips Made from Coarse Sawdust

The use of large volumes of sawdust for making pulp is of economic importance to the landowner, the sawmill operator, and the pulp and paper industry. Short fiber length in sawdust particles has been the major obstacle in its use as a raw material for making pulp.

In 1959, the Forest Products Laboratory in cooperation with the Station agreed to test several sparse-tooth saws with 12, 18, and 36 teeth. These tests included behavior of the saw at various revolutions per minute and rates-of-feed in producing a range of lumber widths, as well as such factors as power requirements and quality of lumber sawn. They also included pulping tests on chips of standard size produced in a chipper, sawdust chips produced by the 36-inch saw, and saw chips produced by a prototype of the 12-tooth saw in a commercial sawmill.

The first of the saws tested was obtained from J. T. Griffin of Valdosta, Georgia, and was developed jointly by the sawmill owner and a saw manufacturer. The Forest Products Laboratory ran pulping tests on coarse sawdust produced by these sparse-tooth saws.

The sawdust used in these pulping tests had an average particle length of ¼ inch in the fiber direction. It was separated into two fractions by a screen with round openings 3/16 inch in diameter. The sawdust remaining on the screen was termed "sawdust chips" and the sawdust falling through the screen, "sawdust chip fines." Sawdust chips produced from other logs by a 12-tooth saw blade at a commercial sawmill in Georgia were also tested.

Yields of kraft pulps made from commercially produced sawdust chips and from the Laboratory sawdust chips, either alone or in mixture, were not significantly different from yields from conventional chips. Chlorine requirements for bleaching were within the normal range for kraft pulps. Results indicated that coarse sawdust chips were slightly easier to pulp than conventional chips. However, the sawdust chip fines were less readily pulped.

Both bursting and tearing strengths decreased as the wood particles became smaller. However, strength properties of pulp from sawdust chips indicate that these were sufficiently strong for use alone or in mixture in many kraft papers.

Preservative Treatment of Turpentined Poles

Companies that purchase longleaf and slash pine poles for preservative treatment have differing acceptance practices for bark-chipped acid-treated poles, predicated on the varying experiences they have had with penetration and retention of preservatives in the area of the turpentined faces. Exploratory penetration and retention tests on turpentined poles were made in south Georgia in 1948 and again in 1957, but results were erratic, and indicated the need for more study.

In view of this need, the Langdale Company offered to cooperate with the Southeastern Forest Experiment Station and the Georgia Forestry Commission in a third study which would involve poles seasoned for different lengths of time and treated with and without initial steaming. The first phase of this study involved a single species, slash pine, and was completed this year.

A representative sample of turpentined poles (fig. 57) was seasoned for various lengths of time, treated with creosote by the usual commercial practice, and tested for penetration and absorption in the turpentined faces (fig. 58). Moisture content and penetration determinations were made by Station personnel and retention analysis was conducted by the Wood Preservation Division of the Forest Products Laboratory.

Figure 57.—Turpentined faces on utility poles used in this study.

Figure 58.—Random selection of test cores from the acid-treated faces.

A total of 80 poles was treated; 20 green, 20 air-seasoned for 30 days, and 40 air-seasoned for 90 days. Of the 40 seasoned for 90 days, 20 were not steam treated prior to preservative treatment. All poles were treated for a retention of 10 pounds per cubic foot except those seasoned for 90 days and not steam conditioned. These were treated for a retention of 8 pounds per cubic foot.

Data indicate that all poles air-seasoned 30 and 90 days and steamed before treatment were adequately penetrated with preservative. The green poles that were immediately steamed and treated had 7 out of 20 poles with unsatisfactory treatment, and the 90-day air-seasoned and unsteamed poles had 14 out of 19 poles with unsatisfactory treatment.

A similar study is now under way with longleaf pine poles seasoned for 30 and 90 days and steam-conditioned before treating. A final report of this project will be prepared when data from the longleaf pine study are available.

A Problem in Mismanufactured Lumber

The furniture manufacturers of North Carolina have been acutely aware that a serious problem exists in the large volume of mismanufactured lumber received at their plants. This fact was emphasized in 1955 when a study showed that approximately 10 percent, or 14 million board feet, of the lumber received was outside specifications. This meant rejection or remanufacture at considerable expense to the furniture industry. A second study was made in 1958 to determine the volume of mismanufactured lumber received at North Carolina furniture plants under revised NMLA rules which call for tighter restrictions on thickness specifications.

Ten furniture plants were selected for sampling on the basis of geographic location and the amount of lumber received. Five individual samples, each from a different supplier, were taken at each of the ten plants.

A sample from each load consisted of 50 randomly selected boards. Every board, 2,500 in all, was calipered in six places for thickness, measured for length and width, and graded. The lumber was then classified as nominal or mismanufactured; the latter category included all rough, green, hardwood lumber that was miscut, oversize, or scant (fig. 59).

An 11.0 percent sample was taken from the 50 loads of lumber. In board-foot measure, this sample amounted to 14 M board feet taken from a total volume of 125 M board feet. Of the 14 M board feet, 30 percent by volume (4,200 board feet) was found to be mismanufactured. Table 14 shows the percentage breakdown of mismanufactured lumber according to the various classes studied.

On the basis of these findings, and knowing that North Carolina furniture plants purchase approximately 140 million board feet of sawn hardwood lumber per year, it can be assumed that about 42 million board feet of this lumber is mismanufactured over the same period. These facts point out the magnitude of the problem.

In an effort to alleviate the problem, future work will be aimed at case studies of sawmills manufacturing at low levels of precision and efficiency. This will involve determining the most common sawing, edging, and trimming errors with subsequent corrective action, and will lead to an effective program of instruction through sawmill clinics.

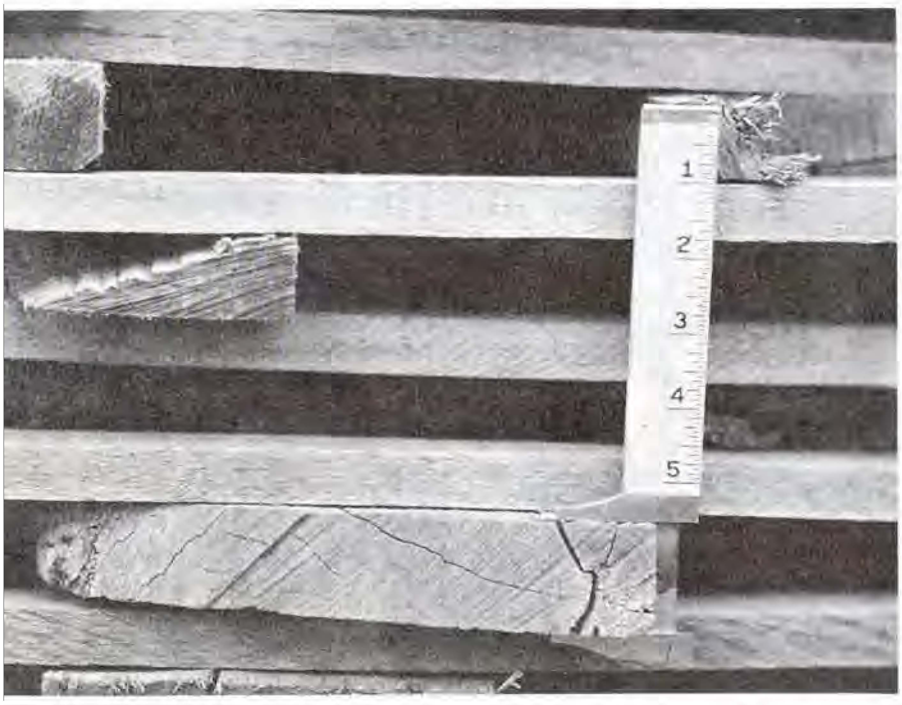


Figure 59. — Wedge-shaped boards are termed "miscut." They cause undue waste and place an extra burden on planer knives.

Table 14.—Relative volume of nominal and mismanufactured lumber received at North Carolina furniture plants

Class of lumber	Percent of volume [1]
5/8, 3/4, 4/4, 5/4, and 6/4 nominal	70.0
Oversize	8.6
Thin	4.8
Miscut	16.6
Total	100.0

[1] Based on sample of 50 loads of lumber.

Tensionwood in Hickory

In cooperation with Clemson Agricultural College, several studies have been completed on tensionwood in hickory. The first study showed that hickory trees which split severely contained greater amounts of gelatinous fibers than trees which did not split. Because this difference was statistically significant, it is assumed to be a true difference. Also, the distribution pattern of tensionwood in splitters and non-splitters was found to be somewhat different.

A second study showed gelatinous fibers in relatively large amounts over the entire cross

section of a straight, severely split tree. Four radii were examined at each 8-foot interval along the merchantable length of the tree. Gelatinous fibers were found in almost all annual rings on all four radii at all levels except the stump. In this study, the non-split trees, of which one leaned and one did not, showed a concentration of gelatinous fibers on the upper side of the lean, which is typical of the distribution in a leaning tree.

In 1948 Jacobs showed that greater stresses are developed in tensionwood than in normal wood. In view of this, it is probably reasonable to assume that relatively large amounts of gelatinous fibers, distributed more or less uniformly throughout the cross section of the tree, contribute to the development of internal stresses which are severe enough to cause excessive splitting.

Forced-Air Drying of Lumber

Research in forced-air drying of 4/4 pine lumber at Athens was described in the 1958 annual report. This work was done in a converted dry kiln and in specially constructed wind tunnels.

Additional tests were made using thin stickers. Tests conducted simultaneously in 3 wind tunnels using 1-inch, ¾-inch, and ½-inch stickers show that drying time is increased with thinner stickers (fig. 60). These differences, however, may not be important when compared with the increased volume of lumber in the predrier. Further studies are needed to weigh all factors, such as greater power consumption, air blockage when warping occurs, and sticker breakage.

Replications have confirmed the 1958 tests and all data are now being prepared for publication. As a part of the over-all predrying study, initial testing of a commercial forced-air drier (fig. 61) near Athens was begun this past summer. This drier has a capacity of 30 M board feet of 4/4 lumber and provides cross circulation with automatic fan reversal at set intervals. Supplemental heat is supplied by a fuel oil burner which is controlled by a humidity-sensing instrument. In the initial summer tests, rough green and partially seasoned 4/4 pine was dried in 6 days to an average final moisture content of 18 percent without supplemental heat. Air velocities averaged 600 feet per minute. More studies are under way on the use of additional heat and the cost of drying.

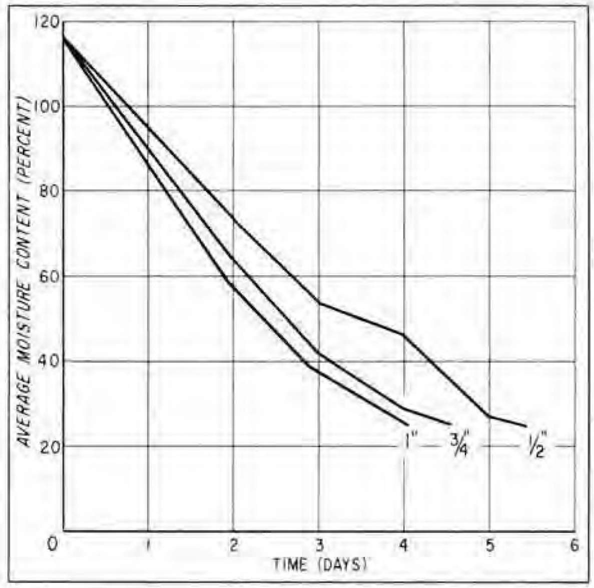


Figure 60.—Effect of sticker thickness on drying time of 4/4 southern pine lumber.

Figure 61.—Pilot plant forced-air lumber drier at Athens, Georgia.

Pine Log and Tree Grade Studies

Separate log and tree grade studies of pine have been conducted during the past 10 years in South Carolina, Georgia, Florida, Mississippi, and Arkansas. Variations in grade yields for similar logs at these separate locations could not be accounted for by measured variables. The difference in sawing techniques and difference in lumber grading provided a possible clue to the variations.

In 1959, trees were collected from each of the original study locations and shipped to an efficient mill in south Georgia where the sawing and grading variations could be eliminated. The data obtained in this study are still under intensive analysis but results obtained so far indicate much less variation than occurred in the original studies.

Using grade 2 logs of similar size and defect pattern, it was found that only one area (Mississippi) resulted in appreciable variation in lumber grade yields (table 15). Further analysis is needed to determine the importance of this variation. In general it appears that the grading system can be used with reasonable confidence throughout the range of the species without the need for local grade-yield studies on each appraisal area, and that differences in sawing techniques can cause much greater variation in lumber grade recoveries than differences caused by geographical locations.

Wood Moisture Content in Homes

Since 1957, the Station, with the cooperation of the Southeastern Dry Kiln Club, has collected data on the equilibrium moisture content of wood in homes throughout the Southeast. This past year, the club began recording moisture content of semi-finished and finished specimens in addition to the unfinished specimens. These two new sets of specimens were coated with a furniture finish; the semi-finished were given coats on three sides with the fourth side uncoated, and the finished were coated on all four sides. When these specimens are located in different areas of the home, they will in effect simulate finished furniture by reflecting the changes in moisture that furniture undergoes.

When moisture content data for the unfinished, semi-finished, and finished speciments were plotted, the semi-finished and finished speciments showed a slower reaction to changes in moisture conditions. This effect was expected because finishes tend to retard the gain and loss of moisture of wood. The following average moisture contents taken over the last six months of 1959 help to substantiate this point. The averages or midpoint of ranges are: unfinished, 10.3 percent; semi-finished, 8.5 percent; and finished, 8.4 percent.

Typical conditions in the living area and basement of a home in Virginia are shown in figure 62.

Table 15.—Variation in lumber grade recovery from No. 2 pine logs from five states

Source of logs	Species	Average age of trees	Average site index	Recovery by lumber grades					
				B & B	C	D	1C & 1 Dim.	2C & 2 Dim.	3C & 3 Dim.
		Years		Percent					
Georgia	Loblolly	63	73	20	12	20	28	14	6
South Carolina	Loblolly	59	85	14	9	21	31	20	5
Arkansas	Shortleaf	72	73	20	12	27	27	14	0
Mississippi	Loblolly	66	73	44	9	13	25	6	3
Florida	Longleaf and slash	73	60-82	21	12	17	36	10	4

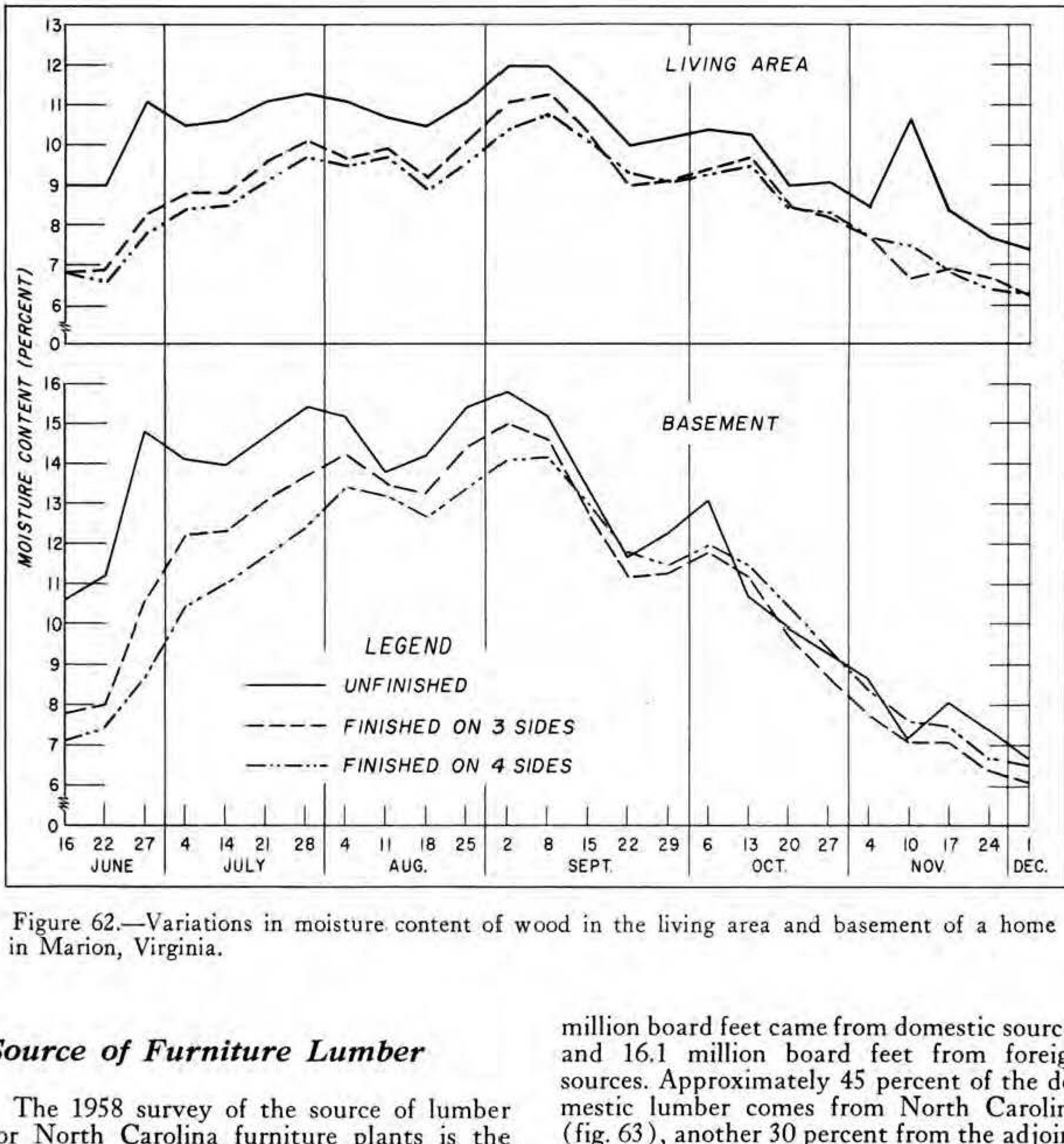


Figure 62.—Variations in moisture content of wood in the living area and basement of a home in Marion, Virginia.

Source of Furniture Lumber

The 1958 survey of the source of lumber for North Carolina furniture plants is the second one conducted through the cooperative efforts of the Furniture, Plywood and Veneer Council of the North Carolina Forestry Association and the Southern Furniture Manufacturers Association. The first survey was made in 1953.

Fifty-four concerns which manufacture 62 percent of the furniture produced in North Carolina reported volume of lumber received by species and source. These volumes were expanded to an industry-wide total on the State level.

Results show that the furniture plants of North Carolina received a total of 321.5 million board feet in 1958. Of this amount, 305.4 million board feet came from domestic sources and 16.1 million board feet from foreign sources. Approximately 45 percent of the domestic lumber comes from North Carolina (fig. 63), another 30 percent from the adjoining states of South Carolina, Georgia, Tennessee, and Virginia, and the remaining one-quarter from the Deep South and central states. A small percentage is brought in from other areas of the United States.

Yellow-poplar accounts for 37 percent of the domestic lumber used (fig. 64), the gums 19 percent, oaks 12 percent, maples 7 percent, and yellow pine 5 percent. No other single species accounts for more than 4 percent of the volume.

About half of the domestic lumber is shipped to North Carolina by rail, and half by truck. Truck transportation is principally from North Carolina and adjacent states.

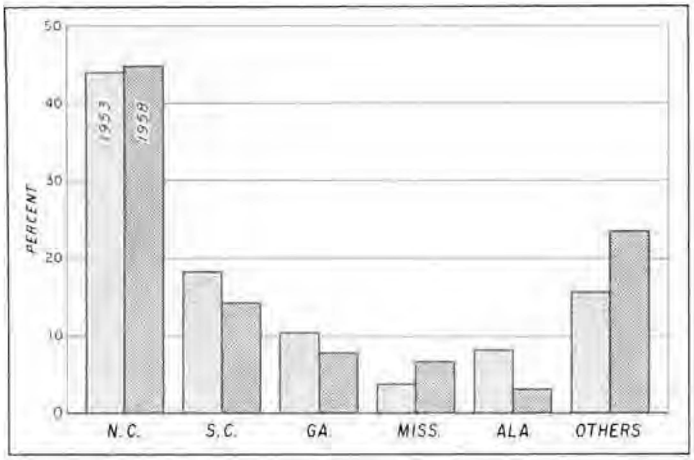


Figure 63.—Source of lumber used in North Carolina furniture plants.

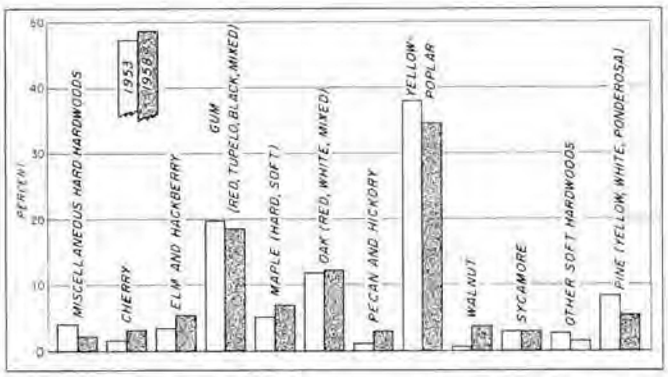


Figure 64. — Lumber used in North Carolina furniture plants by species.

Service Activities

Service activities by the Division have been characterized by increased technical assistance to industry and an extensive information-education program.

Considerable technical aid has been given in developing a method of making charcoal from fine residue by continuous carbonization.

During the past year, Division personnel have closely followed the development of a sparse-tooth saw to produce coarse sawdust for pulp, and have cooperated with industry in evaluating this method of sawing.

A market survey is currently under way to determine the possibility of additional hardwood industries in Georgia.

Detailed inspections of dry kilns and drying schedules were made at a western North Carolina dimension plant and at a Georgia veneer and plywood company. Recommendations based on these inspections should enable the plants involved to dry lumber faster and with less degrade. A number of air-seasoning yards were visited and suggested changes recommended to expedite drying and to eliminate blue stain.

In addition to these projects, Division personnel assisted in solving other wood utilization problems by numerous plant visits and through correspondence.

Papers were presented to technical groups covering a variety of subjects. Among these were discussions on sawing for grade, predrying research, moisture content of wood in homes, stabilizing wood, continuous carbonization of fine residue, current developments in seasoning wood and residue utilization.

Training schools were conducted to acquaint foresters with utilization problems. A number of sawmill clinics were held for mill owners and operators in north and south Georgia. Talks were presented to various civic organizations and to schools emphasizing the need for more efficient wood utilization.

RANGE

Problems arising from attempts to integrate cattle and timber management are being explored on the Alapaha Experimental Range near Tifton, Georgia, and on the Caloosa Experimental Range near Fort Myers, Florida. On the Alapaha, in cooperation with the Georgia Coastal Plain Experiment Station and the Agricultural Research Service, cattle-forage responses are being compared to provide guides for utilizing available forage in slash-longleaf pine forests managed primarily for timber. On the Caloosa, studies of cattle stocking rates and utilization of pineland threeawn (wiregrass) will provide information for managers of cattle-timber enterprises in the cutover flatwoods of South Florida.

Methods of controlling gallberry—an undesirable invader of southern ranges—have been developed at the Alapaha, and J. B. Hilmon, on academic leave from the South Florida project, is studying the problem of saw-palmetto in his doctorate program at Duke University.

CATTLE INJURY TO PLANTED PINES

As the South moves ahead with its huge tree planting program, attention focuses naturally on all factors influencing ultimate timber yield. A prime factor in the flatwoods country is the cow. Timber growers and ranchers often ask, "What injury can I expect if I graze my new tree plantations with cattle at reasonable rates of stocking?" Crucial decisions hinge on knowing how soon the young stands can be safely grazed; whether tree damage can be mitigated by fertilization, feed supplementation, or special practices; and what the grazing impacts are on tree growth and quality after plantations reach sapling and pole size.

Although the Station's range research has not progressed to the point where type and degree of cattle injury can be equated with timber yield, some interim results are interesting. At Alapaha, injury to seedlings has varied from very little in open range plantings where cattle have access to ample amounts of burned range or improved pasture, to excessive where cattle were confined to small plantation pasture units. In most cases tree size, growth stage, and range management procedures apparently had something to do with the degree of cattle injury. Likewise, results on the Caloosa Range show that rate of stocking and age of rough are important factors influencing tree injuries.

Tree Injuries on Open Range and Pastures

In 1959, several hundred pine seedlings were planted in open range and large improved pastures at Alapaha to provide information on the effects of grazing where cattle had a variety of abundant forage. Prior to machine-planting, seedlings were dipped in ZAC (Zinc dithiocarbamate), a cattle repellent developed by the U. S. Fish and Wildlife Service. Undipped seedlings were also planted. Grazing pressure by cattle, with free access to 15 to 20 acres of native range and 0.6 acre of improved pasture per head from March 24 to October 1, caused light use of range forage and very heavy utilization of the more limited amounts of improved pasture.

Frequent observations during the spring and summer showed that injury to young pine seedlings increased rapidly during the period of new shoot development (fig. 65). By late April, 23 percent of the seedlings planted on native range had been injured; thereafter, the number of additional trees injured was more than offset by the number that had recovered from earlier injuries. In pasture plantings, 67 percent of the trees were injured during their first flush of growth (early May); by late summer about 80 percent showed injury. Death of trees planted on open range occurred mostly in June and July, and by October 1, 6 percent were dead. Seedlings planted in pastures suffered heavy losses from May through September, and 65 percent were dead by October 1 (fig. 66).

Because animal damage was almost entirely mechanical, there was no opportunity to evaluate the effect of ZAC on reduction of

needle browsing, and no definite benefits from ZAC were apparent in these trials (table 16). Primarily these 1959 plantings on lightly stocked range demonstrated the relatively low resistance of seedlings to mechanical injury in their first growing year.

Damage to South Florida Pines Under Several Rates of Cattle Stocking

A study of the kinds and degrees of injury to planted pine seedlings under controlled intensities of cattle stocking has been started on the Caloosa Experimental Range. In this study, pastures are stocked with cattle at low, medium, and high rates in season, based on three levels of pineland threeawn utilization: 30, 22, and 15 acres per cow per year.

In January 1959, seedlings of longleaf and South Florida and common slash pine were planted within each of the rated range units. In 6 of the 12 experimental units the range vegetation had been burned off about 60 days before planting; these units were designated 0-rough. Cattle were grazing these units at the time of tree planting. In the other 6 units —designated 1-year rough—range vegetation had been burned off about one year earlier. In accordance with usual grazing practices, cattle were not turned in to graze the 1-year rough until March, about 8 weeks after trees were planted. A fourth intensity of stocking (zero rate) was provided by fencing off newly planted trees against grazing in experimental units of both 0-rough and 1-year rough.

Grazing injury began almost immediately after planting on the 0-rough. In 9 days, 58 percent of the South Florida slash seedlings, 34 of the common slash, and about 4 percent

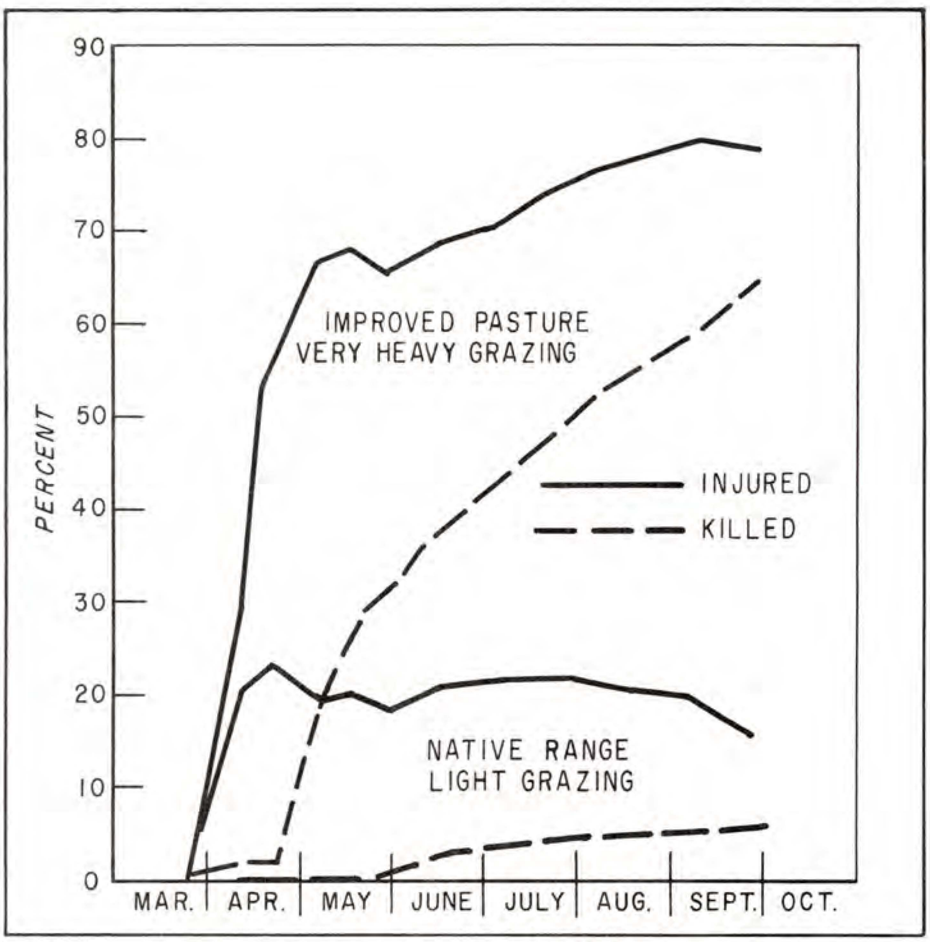


Figure 65.—Percentage of injured and killed trees on improved pasture and native range the first growing season after planting.

Figure 66.—Rubbing and bending of planted slash pine (*left*) caused breakage of the stem and often death of the young trees (*right*).

Table 16.—Spring-summer effects of cattle grazing slash pine seedlings planted on native range and improved pasture, 1959

Observation	Range plantings		Pasture plantings	
	Treated 1/	Untreated	Treated 1/	Untreated
	Percent of trees planted 2/			
0 No grazing injury	89	86	22	23
1 Needles browsed <50%	0	0	0	0
2 Stem bruised	0	--	7	4
3 Needles browsed >50%	0	0	--	0
4 Stem trampled, not broken	3	3	2	2
5 <50% of lateral buds or branches damaged	0	0	0	0
6 >50% of lateral buds or branches damaged	0	0	0	0
7 Terminal buds grazed or broken	2	2	18	18
8 Stem broken	6	9	50	52
9 Seedling destroyed	6	6	64	65

1/ Bundle-dipped in ZAC (Zinc dithiocarbamate) prior to planting.

2/ Injury percents do not total 100; some trees suffered more than one kind of injury, and each instance of multiple injury was recorded.

of the longleaf showed severe grazing injury in one high rate pasture. This initial injury included needles almost completely browsed, terminal buds bitten off, and seedlings partially to completely pulled from the soil (fig. 67). Similar counts in a low rate pasture at this time showed that only 4 trees out of 150 had suffered moderate to severe grazing injury.

Three weeks after planting, a detailed check of all trees planted on 0-rough showed high percentages already injured in varying degrees in the units with high rate of stocking, but only a few trees had suffered under medium and low rates of cattle stocking (table 17).

Early injury in the high rate units was directly attributable to amount of available forage; i. e., concentrations of cattle and limited amounts of grass in these ranges induced injury by browsing and other disturbances to newly planted trees. In the medium and low rate pastures, there was sufficient forage to prevent this.

First-year data taken in late summer showed striking reductions in survival for the the three pine species subjected to high-rate stocking on 0-rough compared to survival under the other rates (fig. 68). There were no differences in survival attributable to rate where trees were planted on 1-year rough.

While data from this study provide leads on initial injury and the influence of rough age and rate of stocking on tree injury, the real answers can only come when ultimate timber yields are also considered. This means that experiments must carry trees to age 10 years or more so that growth and yield data from stands subject to grazing injury can be compared with expected yields where grazing injury is not a factor.

Table 17.—Trees injured by grazing, 3 weeks after being planted on fresh burn

Cattle stocking	Longleaf	South Florida slash	Common slash
	- - - -	Percent	- - - -
High	31	68	47
Medium	13	16	19
Low	2	2	5

Figure 67.—Severe grazing injury to pine seedlings began soon after planting in freshly burned range. This injury included needles and terminal buds browsed and seedlings removed completely from the soil.

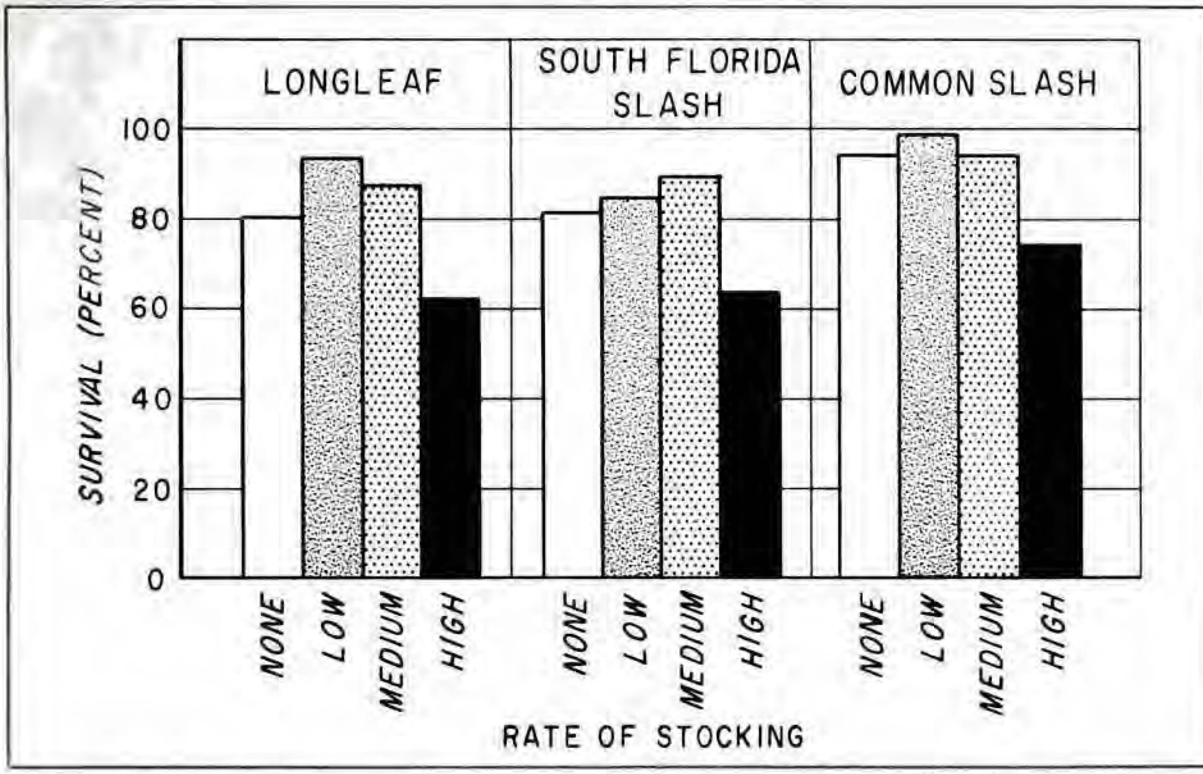


Figure 68.—First-year survival of planted longleaf, South Florida, and common slash pine under four rates of cattle stocking.

WILDLIFE HABITAT

Wildlife habitat research has moved ahead considerably since its inception at the Station in 1958 and several important studies are under way. With few exceptions, the work is developing cooperatively with other agencies, reflecting the widespread demand for managing game resources as an integral part of forest holdings.

Among activities is an appraisal, now getting under way at the Lake City Center, of the effect of site preparation for tree planting on game food and cover plants in the longleaf-slash pine flatwoods. Hunting compartment statistics are being analyzed jointly with the North Carolina Game Division in an effort to assess factors that contribute to deer kill and hunter success. Methods of sampling the relative carrying capacities of deer range are being developed and tested for use in the Timber Survey. An exploratory study of plant succession and soil-water relations on deer range recovering from severe overuse is being planned jointly with the North Carolina National Forests. The latter is a first step toward studying multiple-use aspects of range recovery affecting timber, game, and other resources.

Timber Cutting Affects Deer Browse and Tree Reproduction

During the year, the Asheville Research Center contributed importantly to the Station's developing program in game habitat by reappraising the results of an administrative-type cutting intensity study installed on the Pisgah National Forest in 1949. On three 70-acre compartments, a seed tree cut (all woody plants cut), a modified selection cut, and a standard sawtimber sale cut were made in an area supporting a high deer population. Counts taken in 1951 had indicated a clear relation between cutting intensity and numbers of regenerating stems, and also suggested some large but probably unimportant differences in regrowth with ample browse and tree regeneration in all compartments.

Figure 69.—Seed tree cutting in fairly large blocks may permit satisfactory stand regeneration and provide abundant deer food where browsing pressure is heavy.

Ten years after treatment (1959) comparative stem counts showed substantially more regeneration of commercially desirable species of satisfactory origin in the seed tree compartment than on the area receiving a conventional timber sale cut (490 vs. 149 stems per acre). Also, browse supplies, though not measured, obviously were more abundant on the seed tree cut (fig. 69). Such differences favoring seed tree cutting were apparently due to deer browsing activity, since the earlier count had showed abundant reproduction in both compartments and since the understory in the standard sale area is now typically overbrowsed, with only moderately heavy use apparent in the seed tree cut.

Followup study to determine the effect of a cleaning on the production of resurgent browse, and to improve composition and growth in crop trees is planned. The work will be done by the Center and State Game Division in treated and untreated plots in the original seed tree area. Measurements to compare tree growth, browse production, and deer activity will also be made.

Studies With Penned Deer

First work to determine carrying capacity has been started in an 800-acre deer enclosure located on the Marine Corps Supply Base near Albany in the upper coastal plain in Georgia. This unit will be stocked by the Georgia Game Division with coastal deer. Once established, the over-wintering stocking will be maintained at 30 animals and surpluses will be removed annually by hunting. Pre- and post-season deer drives will provide estimates of herd size. Begun and conducted by the Georgia Game Commission, this study's major emphasis will be the determination of hunting pressure, success values, and animal performance as related to cover change and browsing pressure.

The Albany enclosure typifies recently abandoned old field areas in the upper coastal plain, and probably will produce large quantities of forage for several years. Forage production is expected to reach a high during the 10-year study period, and it is hoped that an over-wintering herd of 30 animals in the 800-

Figure 70.—The Broad Run area was recently opened to hunting by construction of a 9½-mile access road. A continuing study of unrestricted hunting pressure will yield important data on the recreational use of newly accessible areas.

acre tract may approach the carrying capacity at the peak in forage production.

Station participation involves sampling for trends in vegetation as modified by deer browsing activity. A method of point sampling along permanent transects is being used to sample the woody understory. Initial measurements are completed, and exclosures are being constructed to exclude the herd from half the transects. Remeasurement will be carried out bi-annually for the duration of the study.

This study affords excellent opportunities to appraise current deer census techniques and to develop improved inventory methods. Accordingly, the Fish and Wildlife Service has superimposed a census methods study to test for precision and reliability in estimating herd size and distribution.

Appraisal of Current Forest-Wildlife Management Practices

On the Broad Run Area of the Jefferson National Forest, an evaluation of forest-wildlife management systems employed on several large compartments (1500 to 2000 acres) is progressing very well under the leadership of the Virginia Cooperative Wildlife Research Unit.

Area treatments are being evaluated mainly by population response of the principal game animals. Deer herd dynamics have been emphasized in first appraisal efforts, and considerable attention has been given to associated sampling problems.

In addition to appraisals of management systems, the Broad Run compartments provide case histories on hunting pressure and success (fig. 70). Because the area was virtually inaccessible, tabulations on unrestricted hunting pressure will yield information on hunting recreation build-ups in newly accessible and intensively managed forests. Annual inventories, to determine pressure and success values, have been conducted jointly by the Wildlife Research Unit and the Range-Wildlife Division.

Hunting pressure increased approximately 600 percent between the first and second year (250 to about 1435 man-hours), but dropped about 45 percent between the second and third year (down to 775). A gradual increase in pressure is expected, however, during the next few years, corresponding to an observed increase in game supplies, especially deer.

FOREST INSECTS

During most of the past decade our entomologists were beset with epidemics of the tree-killing bark beetles which destroyed many millions of board feet of pine throughout the whole Southeast. As attacks appeared to diminish, there was hope that we could settle down to basic research on bark beetles to determine the reasons for epidemics and to develop sound methods of control. With the decline, however, new problems arose to take the place of the old. Thus, at the end of the decade there are serious outbreaks of pine sawflies throughout the Station territory, and the elm spanworm, the forest tent caterpillar, the fall cankerworm, the oak pit-making scale, the pine needle miner, the pine leaf chafer, and the balsam woolly aphid are active in various sections of the territory. Some of these may require short-term studies; others may require lengthy ones.

As a result of research on the balsam woolly aphid our attention has been focused more rapidly on biological control. Releases of imported predators have been made, and more are anticipated. *Bacillus thuringiensis,* a microbial pesticide, is being explored and looks promising against the tip moth. If we study defoliators more intensively in the near future, we may get into the study of viruses, another promising aspect of biological control.

The ultimate in sound, effective control measures can be developed only through basic research on the organism and on the control techniques involved. We are making an effort toward that goal. Insect research at Lake City and Macon is concentrated largely on one problem and one or two insects at each location. This year a laboratory facility was set up at Bent Creek Experimental Forest and efforts were made toward adequately equipping it (fig. 71).

Balsam Woolly Aphid

Fraser fir on Mt. Mitchell are dying at an accelerated rate from attack by the balsam woolly aphid, *Chermes piceae.* On the basis of various records and studies on rate of mortality, estimates were made on the probable losses occurring around Mt. Mitchell in the years preceding detection of the outbreak in 1957. The following figures show losses of the past five years:

Year	*Number of trees killed*
1955	700
1956	2,000
1957	5,000
1958	11,000
1959	21,000

Figure 71. — One of the insect laboratory buildings at Bent Creek Experimental Forest. The interior has been improved for office and laboratory use. There are two insectaries available nearby.

Aerial and ground surveys of all remaining Fraser fir stands in the southern Appalachians failed to reveal the occurrence of the aphid in any new locations.

A seasonal biology study on Mt. Mitchell showed that the occurrence of three generations per year was common and that a few aphids passed through four generations. This fact, plus the extremely high susceptibility of Fraser fir to aphid attack, may explain the extensive and rapid killing which is taking place. Most of the trees have died after only two or three years of stem attack by the aphid.

The pilot test to determine the effectiveness and cost of control of spraying roadside strips on Mt. Mitchell and the Blue Ridge Parkway began on April 16 and terminated on May 2. During this period 18,000 gallons of a soluble oil spray were applied to about 13 acres of roadside strip in 63 spray hours (fig. 72). Roughly 12,600 trees were treated, and the average amount of spray applied per tree was about 1½ gallons.

Biological control appears to offer a promising method of reducing balsam woolly aphid populations in this relatively small outbreak area where stand conditions, terrain, and costs permit only restricted use of insecticides. Biological control measures were started in June with the release of two species of predators collected in Germany through the cooperation of the Commonwealth Institute of Biological Control, Canada Department of Agriculture, and the Agricultural Research Service of the U. S. Department of Agriculture. A total of 619 *Laricobius erichsonii* beetles and about 10,000 predaceous flies, *Aphidoletes thompsoni*, were released in the vicinity of Mt. Mitchell. Before these almost microscopic flies could be released, it was necessary to rear them to the adult stage under strictly controlled conditions and to isolate and destroy a hyperparasite (fig. 73). Over 3,000 of these tiny parasitic flies were collected and destroyed before the *Aphidoletes* could be released in the field (fig. 74).

Control of the aphid through cutting practices was tried on an experimental basis. Some trees were girdled and some were felled in the fall of the year after most of the aphids had entered dormancy. This was done to dry out the tree and hence cause the death of the insects before spring when they would reproduce. The feasibility of using the tops of felled trees for Christmas trees was explored to offset the cost of this operation. Girdling and felling as a control of the aphid did not prove 100-percent effective because of inadequate drying. However, the population of aphids was greatly reduced.

The aphids were able to move from tops cut for Christmas trees when they were taken into the laboratory the second week of December. This study showed that aphid-infested tops could serve as a source of infestation to uninfested areas.

Figure 72.—Spraying roadside strips of Fraser fir on Mt. Mitchell, North Carolina, to control the balsam woolly aphid.

Figure 73.—Predator of the balsam woolly aphid being reared under rigidly controlled conditions.

Figure 74.—Adults of the predator, *Aphidoletes thompsoni,* being released on an aphid-infested Fraser fir. The cage is removed after the flies lay their eggs and die.

Elm Spanworm

The extent of noticeable defoliation by the elm spanworm, *Ennomos subsignarius,* increased 290,000 acres over that of 1958. Although a total of 860,000 acres of hardwood forest in the mountains of Georgia, Tennessee, and North Carolina were attacked, the intensity of the defoliation was considerably reduced over former years. Unlike previous years, no completely defoliated areas were observed. Indications are that future defoliation will become less severe. However, the adverse effects of repeated defoliation will manifest themselves for several years in reduced tree vigor, loss of growth, and tree mortality (fig. 75).

A study of parasites of the spanworm showed that neither the eggs nor the early instar larvae were attacked. Late instar larvae and pupae were attacked by both Diptera and Hymenoptera; however, control by these parasites was insufficient to affect seriously the spanworm population. Several parasites not previously recorded as attacking the spanworm were recovered.

Because microbial pesticides were reported to control some Lepidoptera effectively, an exploratory study was made to determine the effect of *Bacillus thuringiensis* on the spanworm. Trees were sprayed at various elevations with three different concentrations of the *Bacillus* in water. Examination of larval mortality for several weeks following spraying showed that, under the conditions of the test, the *Bacillus* was only partially effective as a control agent.

Figure 75.—Tree mortality caused by elm spanworm defoliation in Georgia.

Pine Sawflies

Pine sawflies continued to be a problem throughout the Southeast, with populations increasing in some areas and declining in others. In the Piedmont Plateau area of Virginia and North Carolina a marked increase in intensity of feeding by the Virginia pine sawfly, *Neodiprion pratti pratti,* occurred on shortleaf and Virginia pine on over 2 million acres(fig. 76). This is a several-fold increase over the area defoliated in 1958. In Georgia an area of about 500 acres of slash pine was defoliated in the east-central part of the State for the first time. In contrast, sawfly defoliation which occurred on 300,000 acres of loblolly pine in west-central Florida in 1958 drastically declined in 1959. This decline was due principally to natural control factors.

Figure 76.—Area in Virginia and North Carolina defoliated by the Virginia pine sawfly.

Nantucket Pine Moth

During the past year work has continued on the biology of the Nantucket pine moth, *Rhyacionia frustrana.* In particular the activity of the larval stage and egg incubation period have been followed very closely on trees in the field. Previous work indicated that the larvae spent their early life on the outside of the tips and fed on the needles and succulent surface tissue of the developing shoots. This prompted work to follow larval development and activity. Several interesting observations were made. Egg incubation in the spring extended over a period of approximately two weeks. Early larval feeding was external, and it was not unusual to find first instar larvae moving about freely on the developing shoots. Head capsule measurements in the laboratory and observations in the field indicated that internal feeding by the larvae occurs after the third instar. During these first three instars larvae were found to construct webs at different locations on the shoots, but in most cases these were temporary and third instar larvae could occasionally be found crawling about the tips.

A study was made to determine the parasites and predators which attack the Nantucket pine moth in central Georgia and their relative importance. Possibly the most important parasite collected is a small hymenopterous egg parasite, *Trichogramma minutum* Riley; in field collections of tip moth eggs, over 50 percent were found to be parasitized by it. A group of closely related predators of the genus *Phyllobaenus* spp. were the only insect predators found attacking the tip moth. Their great abundance and their ability to devour more than one host undoubtedly make them an important biological control agent.

Exploratory tests of the microbial pesticide, *Bacillus thuringiensis,* showed a high degree of control of early instar tip moth larvae and less control of older larvae.

Insects Destructive to Flowers, Cones, and Seeds of Pine

Studies have been continued at Lake City, Florida, on the insects destructive to flowers, cones, and seeds of slash pine. Emphasis has been given to the biology of the two most damaging species, *Dioryctria abietella* and *D. amatella,* particularly to round out information on their life cycle and behavior patterns (fig. 77).

Research on other associated species is also in progress. Two species of moths which directly injure the seed of pine are under study —*Laspeyresia ingens* and a new species, *L. anaranjada,* collected at Lake City and recently described by Miller in *The Florida Entomologist*. The larvae of both species mine the seed. Several other species of insects are being studied to determine the real importance of their damage to the seed crop. Tests to evaluate schedules and the effect of various formulations of insecticides on *Dioryctria* spp. and *Laspeyresia* spp. have been continued (fig. 78).

Figure 77. — A cutting tool developed at Lake City Research Center enables entomologists to open cones easily and facilitates study of the biology of the insects and the damage they cause.

Figure 78.—During 1959 a field study was conducted at the Lake City Research Center to determine the effectiveness of different spray schedules to control *Dioryctria* spp. coneworms and *Laspeyresia* spp. seedworms attacking slash pine cones. The 0.5-percent BHC water emulsion is being applied to the 45-foot pines by means of a hydraulic sprayer.

Southern Pine Beetle

During the summer about 800 pines were killed by the southern pine beetle, *Dendroctonus frontalis,* on the General Pickens District of the Sumter National Forest in South Carolina. Control measures were quickly put into operation to prevent further spread. All land-managing agencies involved in the latest serious epidemic were warned to check their stands carefully. Aerial surveys of these stands revealed no new outbreaks.

On the basis of 1958 findings that 95 to 100 percent of the hibernating stages were killed the previous winter by subzero temperatures, it was predicted that southern pine beetle populations would likely be at a very low level in 1959. These predictions were correct, except for the small flareup described above.

Surveys in the spring in eastern North Carolina failed to reveal any new beetle outbreaks. A fall survey of the same area uncovered a small population buildup in several hundred infested trees.

Limited exploratory studies and observations were made to determine the nutritional and environmental requirements of the southern pine beetle. This was done in the hope of developing a method for rearing quantities of beetles for biological studies and for determining conditions under which outbreaks occur.

Black Turpentine Beetle

Attacks by the black turpentine beetle, *Dendroctonus terebrans*, in living trees were uncommon this year. Some buildup of beetle populations occurred in South Carolina, Georgia, and Virginia in local areas where logging occurred or where trees were weakened by lightning. In Virginia some control work was done by spraying stumps and the bases of injured trees with 1-percent benzene hexachloride in fuel oil. In no case did activity extend into adjoining uninjured healthy trees.

Ips Engraver Beetles

An operational survey covering over 6 million acres was made in eastern Georgia and southeastern South Carolina during the summer in response to reports of abnormal losses caused by *Ips*. On 3 million acres of pine type, nearly 160,000 dying trees were observed. *Ips* beetles were the principal cause of most mortality. This survey, as well as other observations, demonstrated that *Ips* losses were comparatively low during 1959.

Pine Root Aphids

White pine blight, which is characterized by dieback, shortening, and chlorosis of needles, or a combination of these symptoms, has been recognized by pathologists for many years in eastern United States. Its cause, however, remains to be determined. Some believe that it is a disease or a complex of diseases. Because aphids are commonly found feeding on the roots of white pine, there is a theory that they may contribute to the blight.

A study was started in cooperation with the Division of Forest Disease Research to determine whether aphids might be involved. Insecticides were applied to the root area and the foliage of diseased white pine in eastern Tennessee in order to control any insects which might be present. If the trees recover from the disease symptoms, a basis will be established for further research into the role of insects in causing the blight.

Collections of aphids have been made from roots of white pine and their occurrence has been observed. The species involved are unknown because adult winged forms, upon which classification is based, had never been collected previously. By making periodic collections of immature aphids this year and holding them in the laboratory for continued development, winged adults have been obtained. There appear to be two different species and sample specimens have been forwarded to specialists for identification.

WATERSHED MANAGEMENT

During the year, progress was made in basic studies of water disposal processes of forest lands at both the Coweeta Hydrologic Laboratory in the mountains of western North Carolina and at the Union Research Center in the Piedmont of South Carolina.

At Coweeta an effective start was made on a study of the hydrology and dynamics of soil moisture storage and movement on steep mountain slopes. This research utilizes a new soil model and other apparatus, and essentially involves a critical re-examination of our concepts as to the source of base flows which sustain small mountain streams during dry periods.

In a current Coweeta study, a new look is being taken at conventional hydrologic concepts and their applicability to analyses of runoff data from small mountain streams. Another recent study reports on the influence of mountain topography on solar energy relationships affecting evapotranspiration loss. These studies were thesis problems which Alden Hibbert and Lloyd Swift, Jr., worked on in fulfillment of requirements for their Masters' degrees.

John Hewlett continued work toward his doctorate at Duke University, majoring in studies of moisture tension relationships in forest trees as possible indicators of water-use requirements. This marks first Station efforts toward basic study of some of the plant physiological factors affecting water losses, particularly the internal water balance mechanisms which may control water use demand. Hewlett has served as Acting Center Leader at Coweeta, following transfer in June of Donald Whelan to the U. S. Southeast River Basins Study Commission in Atlanta, and he has continued to give general guidance on technical phases of the Coweeta work since his return to Duke in September.

New work at Union by James Douglass features studies to develop more efficient sampling techniques for quantitative measurement of soil moisture in forest stands.

SOIL MOISTURE STUDIES HOLD MANY ANSWERS IN WATERSHED MANAGEMENT RESEARCH

For many years most watershed management research has featured measurement of runoff response from small drainage units in testing effects of watershed treatment. Generally, the aim has been to evaluate the effects of plant cover and land management practices on water yield, on sediment production, or on evapotranspiration loss; studies of small watersheds usually afford the most direct gross measure. More useful evaluations, however, could probably be made if we knew more about the water demands of various types of watershed cover and how they affect the water regime of soils. Thus, soil moisture studies should assume much greater importance in water management research because they not only can supply needed answers but will enable better interpretations of watershed processes and why they operate the way they do.

Soil moisture studies already have played an important role in research activities both at Union and Coweeta. At the former, Colman electrical-resistance units were utilized in a 7-year study of the soil moisture regime of some typical Piedmont cover types. This investigation compared the influence of pine, pine-hardwood, native broomsedge grass, and no cover (bare soil) on moisture depletion, rainfall recharge, and storage capacity relations for soil profiles to a depth of 66 inches.

In summary, the Union study showed that moisture recharge and depletion are cyclic, recurring in about the same pattern each year with only minor variations due to climate. However, there was no measurable difference in the rates at which soil moisture was depleted under several forest cover types; i. e.,

a young loblolly pine plantation, older shortleaf pine, or mixed pine-hardwood stands.

As between tree and grass cover, the rate of moisture loss varied by depth. Moisture depletion under the broomsedge cover was confined almost exclusively to the surface 30 inches of soil; under deeper-rooted forest vegetation, water was withdrawn to depths of 66 inches. Figure 79 compares the moisture levels observed under pine and broomsedge during 1952. It shows that by November—marking the end of growing-season moisture depletion and the beginning of the soil moisture recharge period—the aggregate difference in moisture levels amounted to more than 6½ inches of water.

Figure 80 compares depletion rates from a 66-inch profile under pine, broomsedge, and barren plots. The evaporation rate (represented by the depletion curve for bare soil) was considerably less than the rate of loss (evapotranspiration) from vegetated plots. Presumably, differences in rooting habits account for the greater moisture depletion on the pine plot. Broomsedge roots, restricted mostly to the upper 30 inches, come in contact with less soil moisture and consequently deplete water at a slower rate than pine.

These findings suggest that trees and other deep-rooted vegetation use much moisture and thereby create more space for intake and storage of winter rains, with consequent reduction in damaging stormflows. Also, it may logically be surmised that water yield from shallow-rooted grass cover exceeds that from the deeper-rooted pine, but at this stage no easy generalizations are possible. Whatever the water demands of various types of plant cover, this in no sense means keeping soils barren as a method of management nor dispensing with forest vegetation as an efficient protector and regulator of soils and water supplies.

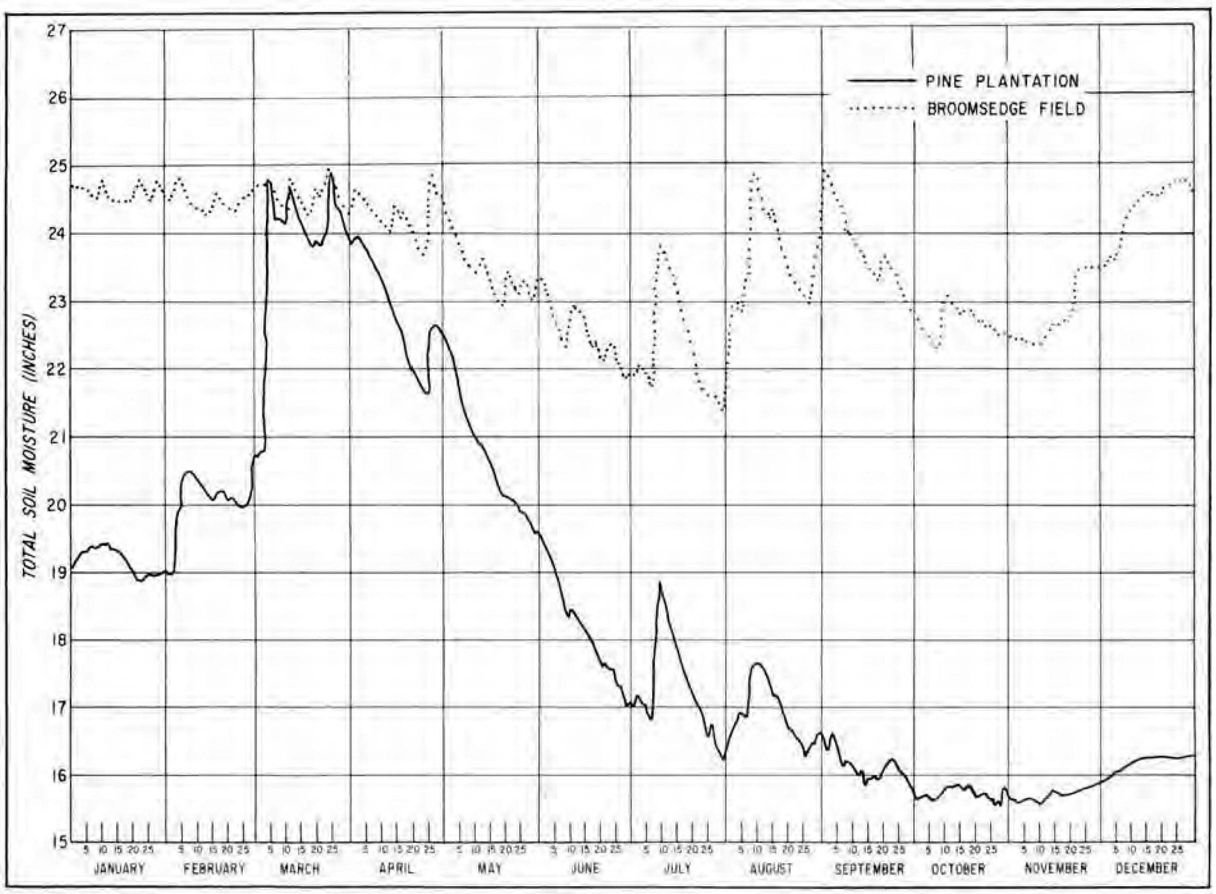


Figure 79.—Soil moisture regime in a pine plantation and native grass field to a depth of 66 inches (1952).

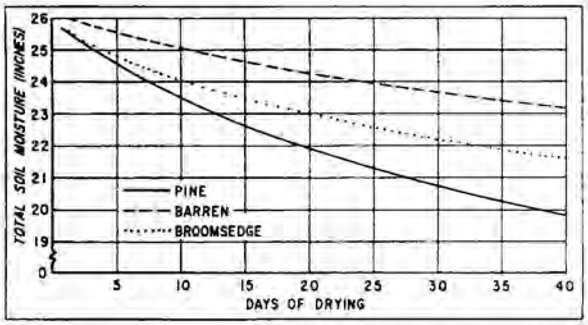


Figure 80.—Soil moisture depletion of the 0 to 66-inch zone of a pine plantation, broomsedge field, and barren plot.

Thinning Studies

Thinning timber stands offers one means of increasing streamflow, although it will take much basic and applied research to document the possibilities and enable reliable predictions of treatment response. At Union, a recent study was made of the effect of thinning a young loblolly pine plantation on soil moisture trends. Although there were some limitations in measurement method, definite dissimilarities were observed in depletion and storage trends under thinned and unthinned stands.

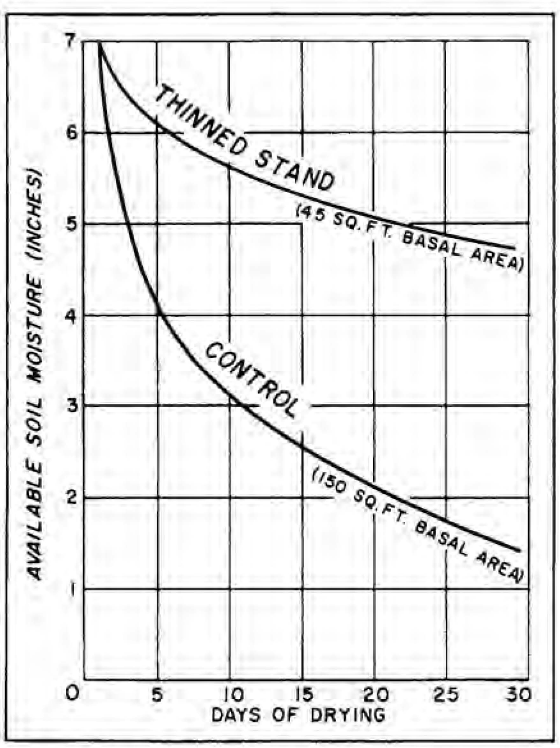


Figure 81.—Soil moisture depletion to a depth of 66 inches under thinned and unthinned loblolly pine stands.

Figure 81 compares soil moisture for the two levels of tree stocking and shows that the unthinned stand, with 150 square feet of basal area, used about 3 inches more water than the heavily thinned stand with a basal area of 45 square feet per acre. Although the difference in these preliminary observations may not seem particularly impressive, it suggests that commercial thinnings can substantially reduce evapotranspiration loss and thus may change water storage and yield relationships appreciably.

There were marked differences in distribution of moisture in the heavily thinned stand. For example, at the end of the growing season, the available storage space for winter rains in the upper 48 inches of soil at a point midway between trees (spaced 20 x 20) was about 4.4 inches, or little more than half that available directly beneath the trees (fig. 82). In contrast, the available storage space as gaged by moisture measurements was greater and was quite uniformly distributed between trees spaced 6 x 6 in the unthinned stand.

These findings, though exploratory, have important implications to watershed managers who must rely heavily on manipulation of cover, such as tree thinnings, to increase or decrease streamflow. Some well-known

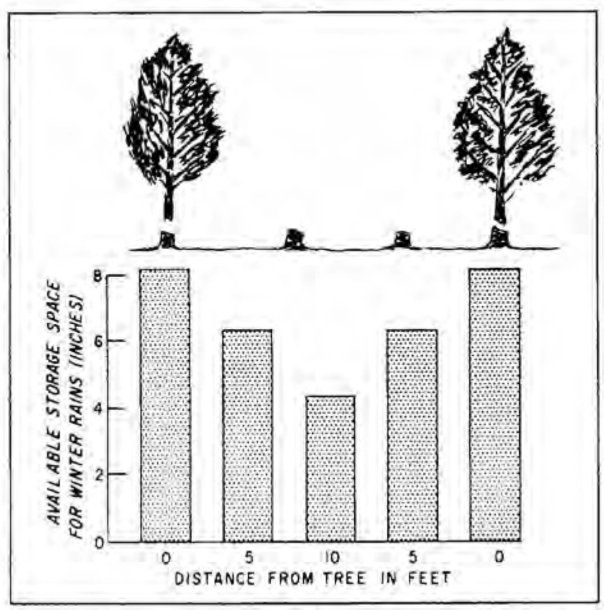


Figure 82.—Distribution of water storage capacity in a thinned loblolly pine plantation (upper 4 feet of soil) at end of the first growing season.

studies at Coweeta have shown conclusively that under conditions there, very substantial increases in regulated flows (up to 17 inches annually) can be obtained by cutting all forest vegetation, and that while water yields decline as watershed cover grows back, the increases persist in some degree many years after a single cutting operation. Naturally, much interest centers on whether changing the cover type as an adjunct to cutting itself will appreciably affect water yields.

Type Conversion Studies at Coweeta

An important major study at Coweeta, started in 1955, will compare the long-term water yield responses from a series of calibrated watershed units representing native hardwood forest, white pine on north and south aspects, a perennial grass, and low shrub cover. Conversion of a 22-acre unit from high forest to grass was accomplished during the past year (fig. 83). Kentucky 31 fescue was hand seeded on the steep slopes after a heavy application of 2-12-12 fertilizer and lime and a later top dressing of ammonium nitrate. An excellent grass cover was quickly established with minimum disturbance to soil and little apparent effect thus far on streamflow (fig. 84). This expensive treatment can afford only bench mark values of water yield changes after conversion to shallow-rooted grass cover; treatment will doubtless be difficult to maintain. Nevertheless, it is one key research approach to the whole problem.

It would greatly strengthen the Coweeta "type conversion" study to know something at this stage about soil moisture depletion trends under hardwood forest and grass and about the rooting habits, internal water economy, and other attributes of these cover types. Thus far, an exploratory Coweeta plot study of soil moisture regimes under hardwoods and grass shows little difference in moisture losses from the two covers. During winter and early spring, the mean daily loss in soil moisture from grass cover slightly exceeded that from hardwood forest, but during

Figure 83. — Watershed at the Coweeta Hydrologic Laboratory after conversion from mountain hardwood high forest to a fescue grass cover.

Figure 84.—A luxurious stand of Kentucky 31 fescue was established on this Coweeta watershed in a single growing season. The purpose was to ascertain whether conversion to a grass cover will increase water yield.

the summer the daily loss from hardwoods was greatest (fig. 85). These are preliminary results and should not be interpreted as meaning that such diverse types of cover as hardwoods and grass make the same water demands. These first observations, however, point to some interesting seasonal relationships which merit followup study.

Techniques of Measuring Soil Moisture

Although soil moisture studies afford one of the more fruitful approaches in water management research, they have been badly handicapped by lack of efficient measurement

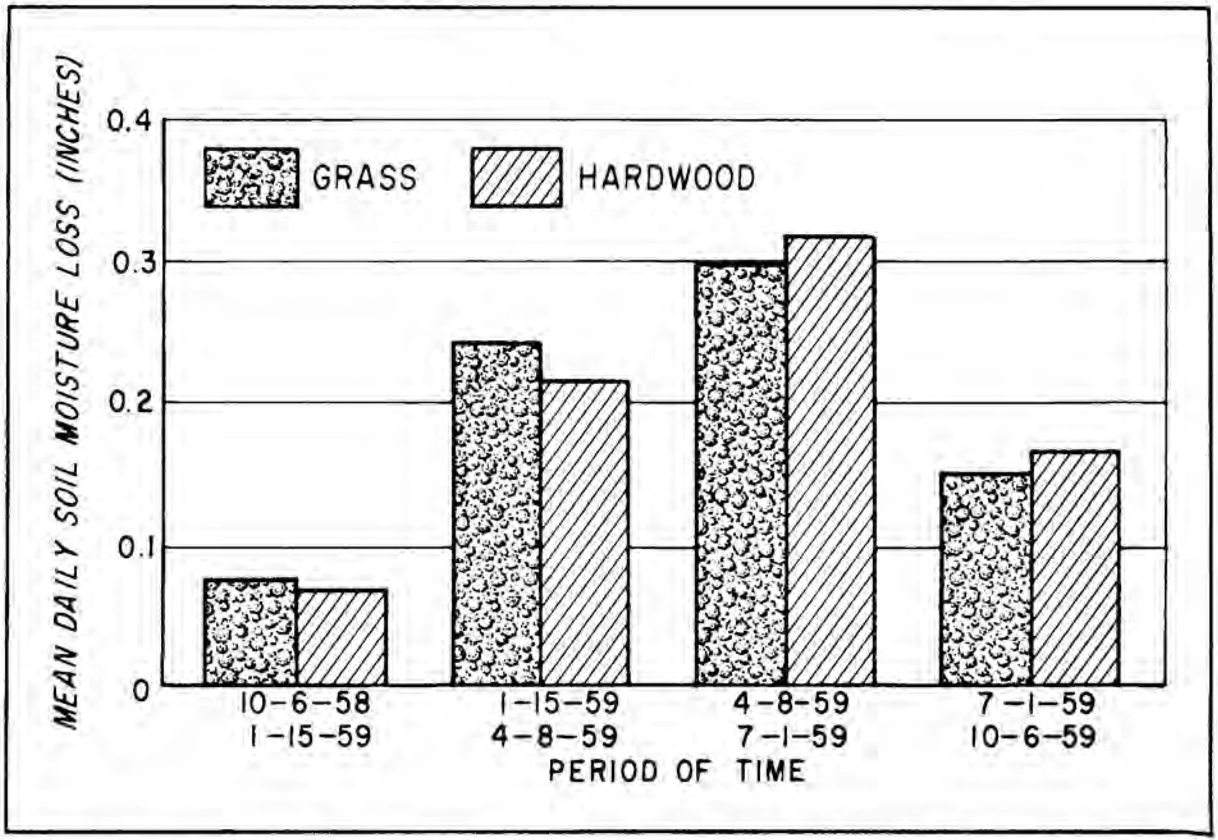


Figure 85.—At Coweeta, moisture losses from grass cover were higher in winter and lower during the summer than losses from a nearby hardwood cover.

techniques. Consequently, much of the work to date at Coweeta and Union has been devoted to studies to develop better and more reliable ways and means of measuring soil moisture. A publication describing a methed of calculating precision of estimates of soil moisture volumes will be released shortly. It suggests techniques for substantially increasing experimental precision. Correlation between bulk density of the soil and percent moisture by weight was found to be high on samples taken close together (r= —0.76). Thus, to take advantage of covariance, the authors propose use of sample clusters and offer a method for calculating the error of moisture estimates. At Coweeta, accounting for covariance reduced the number of samples required to estimate moisture at a given level of precision by as much as 75 percent (table 18).

A new neutron meter utilizing a radioactive moisture probe is proving accurate and reasonably reliable at Coweeta and Union and opens up exciting new possibilities in moisture investigations (fig. 86). A chief advantage is that remeasurement of the same soil mass is possible, and direct measurement of moisture volumes can be obtained rapidly. Replication is feasible and studies can be established with sound statistical planning. At Union, investigations are under way to determine field experimental design requirements of the method, precision of moisture estimates, and sample numbers required for specified confidence levels. Guidelines for more efficient use of the equipment will be developed.

The effective depth of rooting of pine is also being studied by the nuclear method. Studies which measure moisture to 6 and 8 feet may not sample water withdrawal effects on the whole soil profile because some roots may penetrate considerably below this level. Some years of study may be required to learn what the rooting-depth limits are, particularly since it may be only during dry years that vegetation exerts strong draft on moisture deep within the soil.

Table 18.—Number of Coweeta sample clusters required to hold expected standard error of moisture estimates to 1 percent by volume

Soil depth (inches)	Without accounting for covariance	Accounting for covariance (r = - 0.76)
	Number	Number
0 - 6	36	9
6 - 12	30	7
12 - 24	27	7
24 - 36	26	9
36 - 48	27	10
48 - 60	28	11
60 - 72	28	12
72 - 84	25	11

Applicability of the method for studying moisture in thinned timber stands and the vital problem of accounting for rainfall recharge through moisture measurements are also under study.

The future in soil moisture research seems highly promising. Once problems of measurement technique are solved, answers concerning storage capacity of soils, moisture recharge characteristics, comparative water use of plant cover types, and other related problems can be answered.

Basic relationships, ascertained through study of soil moisture regimes and substantiated in watershed tests, should provide more valuable and useful data than have previously been available. Moreover, the watershed manager, fortified with such findings, will be better prepared for sound management decisions in altering forest cover to meet water requirements.

Figure 86.—The neutron method holds promise as a reliable and accurate method of determining the volume of moisture held by the soil. It is currently in use in the Piedmont to measure moisture content of soils to depths of 16 feet.

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by
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Calendar Year 1959

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(Stronger acid, larger bark hack, and 2-quart cups particularly suited to intensive work.)

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(Discussion of survey objectives, population characteristics, sampling units, and design with respect to direct seeding.)

Evans, T. C.
GENERAL APPRAISAL OF STATISTICAL PROBLEMS AND NEED. Techniques and Methods of Measuring Understory Vegetation Symposium Proc. 1958: 146-151. Published jointly by South. Forest Expt. Sta. and Southeast. Forest Expt Sta.
(Discussion of sampling methods, sampling units, and field plot experiments as related to understory vegetation.)

Foster, A. A.
NURSERY DISEASES OF SOUTHERN PINES. U. S. Dept. Agr. Forest Pest Leaflet 32, 7 pp., illus.
(Cause, symptoms, and control for damping-off, black root rot, nematode injury, fusiform rust, brown spot, and chlorosis.)

Froelich, R. C.
DEFECT IN MERCHANTABLE SAWTIMBER IS LARGELY VISIBLE. South. Lumberman 198(2466): 34-35, illus.
(The importance of different types of cull in sawtimber as determined by studies in Virginia, North Carolina, and South Carolina.)

Gaby, L. I.
OPERATION PREDRY . . . VARIABLES IN DRYING SOUTHERN PINE. Forest Prod. Jour. 9(5): 23A-26A.
(Reports on drying southern yellow pine lumber with forced-air and on the influence of several introduced drying variables.)

Gruschow, G. F.
INCIDENCE OF ROT IN HARDWOOD SAWTIMBER IN COASTAL NORTH CAROLINA. Jour. Forestry 57: 370-371.
(Data on the incidence and amount of decay, by species, of the hardwood component of 100-year-old loblolly pine stands in coastal North Carolina.)

Gruschow, G. F.
OBSERVATIONS ON ROOT SYSTEMS OF PLANTED LOBLOLLY PINE. Jour. Forestry 57: 894-896, illus.
(Survey of root systems of bar-planted seedlings in southeastern Virginia.)

Gruschow, G. F., and Evans, T. C.
THE RELATION OF CUBIC-FOOT VOLUME GROWTH TO STAND DENSITY IN YOUNG SLASH PINE STANDS. Forest Sci. 5(1): 49-55, illus.
(Relationships between growth per acre, stand density, and site quality in flatwoods of northeastern Florida and southeastern Georgia.)

Guilkey, P. C.
THE INFLUENCE OF VEGETATIONAL LAYERS ON COVER MEASUREMENTS. Techniques and Methods of Measuring Understory Vegetation Symposium Proc. 1958: 101-104. Published jointly by South. Forest Expt. Sta. and Southeast. Forest Expt. Sta.
(Most methods and instruments now available can be adapted for use if the various layers can be defined satisfactorily.)

Haney, G. P., and Metz, L. J.
SILVICAL CHARACTERISTICS OF SOUTHERN RED OAK. Southeast. Forest Expt. Sta. Paper 106. 9 pp., illus.
(Extent and climate of botanical range, edaphic and physiographic site conditions, reproductive and growth habits, ecology, plant and animal pests, and response to management.)

Hepting, G. H.
DISEASE LOSSES IN SOUTHERN PINE SEED DURING CONE PRODUCTION. Direct Seeding in the South Symposium. Duke Univ. School Forestry, 1959: 36-39.
(The most important disease interfering with seed production in a southern pine is the cone rust caused by *Cronartium strobilinum*. Oaks are alternate hosts.)

Hepting, G. H.
FOREST PATHOLOGY IN FOREST MANAGEMENT IN THE UNITED STATES. (Abs.) IX Internatl. Bot. Cong. Proc. 2: 161-162.
(Most research is aimed at practical aspects of causes and control. The fundamentals of behavior of trees and pathogens will be given greater emphasis in future research.)

Hepting, G. H.
MEETING THE PROBLEM OF FOREST DISEASES. Forest Farmer 18(8): 46-48.
(Describes major forest diseases in the Southeast and progress in combating them.)

Hilmon, J. B.
DETERMINATION OF HERBAGE WEIGHT BY DOUBLE-SAMPLING: WEIGHT ESTIMATE AND ACTUAL WEIGHT. Techniques and Methods of Measuring Understory Vegetation Symposium Proc. 1958: 20-25, illus. Published jointly by South. Forest Expt. Sta. and Southeast. Forest Expt. Sta.
(Double-sampling provides faster and more efficient estimates of forage production and utilization on native forage in a rates of cattle stocking study in south Florida.)

Hodges, C. S.
HISTOLOGICAL STUDIES OF ROOTS OF PINE SEEDLINGS INFECTED WITH BLACK ROOT ROT. (Abs.) Phytopathology 49(5): 318.
(*Sclerotium bataticola* and *Fusarium* spp. are associated with the disease and pathogenic in inoculation tests; former produces indolacetic acid, which can cause marked proliferation of root cortex.)

Hughes, R. H.
THE WEIGHT-ESTIMATE METHOD IN HERBAGE PRODUCTION DETERMINATIONS. Techniques and Methods of Measuring Understory Vegetation Symposium Proc. 1958: 17-19. Published jointly by South. Forest Expt. Sta. and Southeast. Forest Expt. Sta.
(Describes procedures and uses of weight-estimate method on range lands of the South and East.)

Johansen, R. W.
MONOAMMONIUM PHOSPHATE SHOWS PROMISE IN FIRE RETARDANT TRIALS. Southeast. Forest Expt. Sta. Res. Note 137.
(Aerially-dropped loads of monoammonium phosphate stopped surface head fires in highly combustible fuels in south Georgia.)

Johansen, R. W., and Kraus, J. F.
FERTILIZING CLEFT AND BOTTLE GRAFT SCIONS IN AN ATTEMPT TO INCREASE GRAFT UNIONS. Jour. Forestry 57: 511, 514.
(Scion-fertilization treatments in the concentrations used did not have a beneficial effect on the success of either cleft or bottle grafts.)

Johansen, R. W., and Turner, J. C.
EFFICIENT USE OF AERIAL TANKERS IN THE SOUTHEAST. South. Lumberman 199(2489): 99-100, illus.
(In open areas, 220-gallon drops of fire retardant material are adequate; in well-stocked stands, 440-gallon drops are required.)

Jones, E. P., Jr.
WET SITE SURVIVAL AND GROWTH. Southeast. Forest Expt. Sta. Res. Note 130.
(Survival and growth of planted yellow-poplar, eastern cottonwood, slash pine, and loblolly pine.)

Keetch, J. J.
UNIFYING FIRE DANGER RATING—PROGRESS TOWARD A NATIONAL SYSTEM. Fire Control Notes 20(3): 87-88.
(A short history of the project to develop a unified national fire danger system and a brief progress report.)

Keetch, J. J., and Gladstone, M. C.
1958 FOREST FIRES AND FIRE DANGER IN MAINE AND RHODE ISLAND.
(Two separate reports containing tables and graphs analyzing forest fires and fire danger.)

Klawitter, R. A.
DIRECT SEEDING HARDWOODS. Direct Seeding in the South Symposium. Duke Univ. School Forestry, 1959: 154-158.
(Results of direct seeding cherrybark, Shumard, and swamp chestnut oak at Charleston, S. C.)

Klawitter, R. A.
PRESCRIBED BURNING CAN PAY ITS WAY. Forest Farmer 18(9): 9, 14-15, illus.
(Logging costs in loblolly pine were substantially reduced by controlling a hardwood understory with periodic winter fires.)

Kowal, R. J.
BIOLOGICAL CONTROL OF BALSAM WOOLLY APHID—WILL IT SUCCEED IN THE SOUTH? Forest Farmer 19(2): 6-7, illus.
(Discussion of balsam woolly aphid problem near Mt. Mitchell and description of efforts to control it by biological methods.)

Kowal, R. J.
MEETING THE PROBLEM OF TREE-KILLING INSECTS. Forest Farmer Manual 18(8): 38-46.
(Progress in improving detection and reporting of insect outbreaks and in research on control of important southern forest pests.)

Kowal, R. J.
SHADE TREE INSECTS IN THE SOUTH—THEIR INCREASING IMPORTANCE AND CONTROL. 34th Natl. Shade Tree Conf. Proc. 1958: 159-171.
(Damage caused to shade trees by some of our common forest insects; recommendations for control, primarily cultural in nature.)

Kraus, J. F.
METHOXONE TREATMENT OF LONGLEAF PINE SEED. Jour. Forestry 57: 650.
(High concentrations of methoxone were toxic to longleaf pine seed; low concentrations did not shorten length of time seedlings stayed in the grass.)

Langdon, O. G.
SITE INDEX CURVES FOR SOUTH FLORIDA SLASH PINE. Southeast. Forest Expt. Sta. Res. Note 133.
(Regression of logarithm of total height on reciprocal of age was computed and expressed in terms of site index at age 25 years.)

Langdon, O. G.
SITE PREPARATION REQUIREMENTS FOR DIRECT SEEDING OF LONGLEAF AND SLASH PINES. Direct Seeding in the South Symposium. Duke Univ. School Forestry, 1959: 109-113.
(Discusses factors limiting initial stand establishment for direct seeding.)

Larson, R. W.
TIMBER IN NORTH CAROLINA. U. S. Dept. Agr. Forest Resource Rpt. 15, 24 pp., illus.
(Illustrated presentation of current timber supply trends, possible future needs, and problems that must be solved to increase timber supply.)

Larson, R. W.
USE OF TRANSECTS TO MEASURE LOW VEGETATIVE COVER. Techniques and Methods of Measuring Understory Vegetation Symposium Proc. 1958: 48-54. Published jointly by South. Forest Expt. Sta. and Southeast. Forest Expt. Sta.
(Describes uses, advantages, and disadvantages of various types of transects, including belt, strip, or line intercept method.)

Larson, R. W., and Bryan, M. B.
VIRGINIA'S TIMBER. Southeast. Forest Expt. Sta. Forest Survey Release 54. 72 pp., illus.
(Statistics on forest and nonforest areas, timber volume, growth, mortality, and cut, with trends in forest area and timber volume between first and second surveys.)

Lotti, Thomas
SELECTING SOUND ACORNS FOR PLANTING BOTTOMLAND HARDWOOD SITES. Jour. Forestry 57: 923, illus.
(Identification of weeviled acorns of swamp chestnut, Shumard, and cherrybark oaks by visual characteristics.)

Lotti, Thomas
A SPECIAL FIRE PLAN FOR THE SANTEE EXPERIMENTAL FOREST. Southeast. Forest Expt. Sta., 26 pp., illus.
(Analysis of such items as 10-year-fire occurrence and protection priorities; detailed action plan for maximum protection of a high-value area.)

Lotti, Thomas, and LeGrande, W. P.
LOBLOLLY PINE SEED PRODUCTION AND SEEDLING CROPS IN THE LOWER COASTAL PLAIN OF SOUTH CAROLINA. Jour. Forestry 57: 580-581, illus.
(Five-year seed production in two 50-year-old stands and seed and seedling losses. One stand had annual summer prescribed burns.)

Lund, A. E., and Taras, M. A.
KILN DRYING CHEMICALLY TREATED SCARLET OAK AND WHITE OAK LUMBER. Forest Prod. Jour. 9(11): 398-403.
(Indicates chemical treatment with salt can help minimize honeycomb degrade when high temperature and rapid drying schedules are used.)

McAlpine, R. G.
FLOODING KILLS YELLOW-POPLAR. Forest Farmer 19(3): 9, 13-14, illus.
(High mortality of yellow-poplar planting caused by flooding during growing season.)

McAlpine, R. G.
IS THERE A FUTURE IN COTTONWOOD? Forest Farmer 18(12): 12-13, 16, 18.
(Reports on 3-year growth and survival of cottonwood plantings in Georgia Piedmont.)

McAlpine, R. G.
RESPONSE OF PLANTED YELLOW-POPLAR TO DIAMMONIUM PHOSPHATE FERTILIZER. Southeast. Forest Expt. Sta. Res. Note 132.
(First-year height growth increased with increasing rates of application of diammonium phosphate (20-52-0).)

McAlpine, R. G.
YELLOW-POPLAR RESPONDS TO FERTILIZATION. South. Lumberman 199(2489): 95-96, illus.
(Second-year measurements show widening gap between plots fertilized with diammonium phosphate and control plots.)

McAlpine, R. G., and Jackson, L. W. R.
EFFECT OF AGE ON ROOTING OF LOBLOLLY PINE AIR-LAYERS. Jour. Forestry 57: 565-566, illus.
(Rooting was best in the youngest age classes and declined sharply with increasing age. None of the air-layers rooted on trees 17 and 20 years of age.)

McGee, C. E.
WEIGHT OF MERCHANTABLE WOOD WITH BARK FROM PLANTED SLASH PINE IN THE CAROLINA SANDHILLS. Southeast. Forest Expt. Sta. Res. Note 128.
(Tables of green weight of wood with bark for trees by diameter and height classes to a fixed top outside bark of 2.0, 3.0, and 4.0 inches.)

McGee, C. E., and Bennett, F. A.
CUBIC FOOT VOLUME TABLES FOR SLASH PINE PLANTATIONS OF THE MIDDLE COASTAL PLAIN OF GEORGIA AND THE CAROLINA SANDHILLS. Southeast. Forest Expt. Sta. Res. Note 129.
(Cubic foot volumes inside bark and outside bark by diameter and height classes to fixed tops outside bark of 2.0, 3.0, and 4.0 inches.)

McGee, C. E., and Bennett, F. A.
SITE INDEX CURVES FOR OLD-FIELD SLASH PINE PLANTATIONS. Southeast. Forest Expt. Sta. Res. Note 127.
(Regression of logarithm of total height on reciprocal of age was computed and expressed in terms of site index at age 25 years.)

Meginnis, H. G.
INCREASING WATER YIELDS BY CUTTING FOREST VEGETATION. Internatl. Assoc. Sci. Hydrol. Pub. 48: 59-68, illus. (Symposium Hannover-Munden, 8-13 Sept., 1959.)
(Discusses increases in water yield by cutting forest vegetation; need for more basic knowledge of water use requirements of cover and of plant-soil-climatic factors which govern evapotranspiration.)

Merkel, E. P.
INSECTS CAUSING SEED LOSSES IN SEED-PRODUCTION AREAS. Direct Seeding in the South Symposium, Duke Univ. School Forestry, 1959: 32-35.
(Describes some of the major flower, cone, and seed insect pests affecting slash and longleaf pines.)

Merkel, E. P., Beers, W. L., and Hoekstra, P. E.
PROBLEMS INVOLVED IN THE CONTROL OF CONE INSECTS BY AERIAL SPRAYING. Fifth South. Forest Tree Impr. Conf. Proc. 1959: 77-81.
(Discusses results of recent aerial spray tests for control of cone insects in South. Recommendations for future aerial spray experiments are considered.)

Metz, L. J.
THE DESCRIPTION AND MEASUREMENT OF THE FOREST FLOOR. Techniques and Methods of Measuring Understory Vegetation Symposium Proc. 1958: 105-113, illus. Published jointly by South. Forest Expt. Sta. and Southeast. Forest Expt. Sta.
(Discusses nomenclature and methods of measurement of components and characteristics of forest floor.)

Metz, L. J., and Douglass, J. E.
SOIL MOISTURE DEPLETION UNDER SEVERAL PIEDMONT COVER TYPES. U. S. Dept. Agr. Tech. Bul. 1207, 23 pp., illus.
(Compares soil moisture regime of pine, pine-hardwood, grass, and bare soil, particularly moisture depletion by depths to 66 inches over a 5-year period.)

Nagel, W. P.
FOREST INSECT CONDITIONS IN THE SOUTHEAST DURING 1958. Southeast. Forest Expt. Sta. Paper 100, 10 pp., illus.
(Discussion of survey and control activities.)

Nelson, R. M.
DROUGHT ESTIMATION IN SOUTHERN FOREST FIRE CONTROL. Southeast. Forest Expt. Sta. Paper 99, 22 pp., illus.
(Suggests tentative method for estimating soil moisture from measurements of mean temperature and precipitation.)

Nelson, T. C.
SILVICAL CHARACTERISTICS OF MOCKERNUT HICKORY. Southeast. Forest Expt. Sta. Paper 105, 10 pp., illus.
(Extent and climate of botanical range, edaphic and physiographic site conditions, reproductive and growth habits, ecology, plant and animal pests, and response to management.)

Olson, D. F., Jr.
SITE INDEX CURVES FOR UPLAND OAK IN THE SOUTHEAST. Southeast. Forest Expt. Sta. Res. Note 125.
(New site index curves for white, northern red, southern red, scarlet, black, and chestnut oaks in Virginia-Carolina Piedmont and Southern Appalachian Mountains.)

Olson, D. F., Jr., and Della-Bianca, Lino
SITE INDEX COMPARISONS FOR SEVERAL TREE SPECIES IN THE VIRGINIA-CAROLINA PIEDMONT. Southeast. Forest Expt. Sta. Paper 104, 9 pp., illus.
(Charts and equations for estimating site index of shortleaf pine, northern red oak, southern red oak, scarlet oak, black oak, and white oak when site index of yellow-poplar is available.)

Olson, D. F., Jr., and Doyle, H. J.
PIEDMONT FARM WOODLANDS. Furniture, Plywood, and Veneer Council of the North Carolina Forestry Association, Inc., Report 5, 18 pp., illus.
(Income, cost, and net profit from woodland operation on two small woodlots in North Carolina Piedmont.)

Page, R. H.
GEORGIA'S HARDWOODS—PROBLEM OR OPPORTUNITY? Cross Tie Bul. 40(12): 37-39.
(Points out overabundance of low-quality hardwoods in Georgia and part that wood utilization research is playing in providing profitable outlets.)

Page, R. H., and Saucier, J. R.
COMPRESSION WOOD. Forest Utilization Serv. Release 20.
(Practical information for recognizing and avoiding deleterious effects of compression wood in pine lumber.)

Peter, R. K.
NEW UNITIZING METHODS FOR PARQUET FLOORS. Wood & Wood Products 64(4): 48, 56-57.
(Proposes and describes several new methods for unitizing parquet flooring that are adapted to fast production and mechanical handling.)

Ripley, T. H., and Campbell, R. A.
THE WHITE-TAILED DEER—A BLESSING AND A PROBLEM. Wildlife in North Carolina 23(9): 14-15.
(Discusses opportunities and problems of managing hardwoods in Southern Appalachians for both timber and game.)

Robinson, V. L.
PULPWOOD PRICE TRENDS IN THE SOUTHEAST. Southeast. Forest Expt. Sta. Res. Note 136. Also in Paper Trade Jour. 143(52): 22.
(Average prices paid in Southeast for pine pulpwood from 1945-1958; separate prices listed for rail wood, yard wood, truck wood, and weighted average for all types of delivery.)

Roth, E. R.
HEART ROTS OF APPALACHIAN HARDWOODS. U. S. Dept. Agr. Forest Pest Leaflet 38, 4 pp., illus.
(Describes important fungi causing basal, top, and trunk decay; methods given for reducing decay losses.)

Roth, E. R., Hepting, G. H., and Toole, E. R.
SAPSTREAK DISEASE OF SUGAR MAPLE AND YELLOW-POPLAR IN NORTH CAROLINA. Southeast. Forest Expt. Sta. Res. Note 134.
(The disease has not spread out of its original restricted range. Inoculations with causal fungus have killed both host species; natural spread and killing are slow.)

Saucier, J. R., and Page, R. H.
A DIRECTORY OF WOOD-USING INDUSTRIES IN GEORGIA. Georgia Forestry Comm. and Southeast. Forest Expt. Sta., Ed. 2, 109 pp.
(Classifies Georgia's wood-using industries by location, type of operation, materials purchased, and products sold.)

Shipman, R. D.
SILVICAL CHARACTERISTICS OF WINGED ELM. Southeast. Forest Expt. Sta. Paper 103, 7 pp., illus.
(Extent and climate of botanical range, edaphic and physiographic site conditions, reproductive and growth habits, ecology, plant and animal pests, and response to management.)

Sluder, E. R.
GROWTH AND THE EFFECT OF PRUNING IN A STAND OF SYCAMORE IN THE SOUTHERN APPALACHIANS. South. Lumberman 199(2489): 145-146, illus.
(Pruning a natural stand of sycamore will result in maximum production of high-quality wood.)

Speers, C. F.
A PORTABLE FIELD CAGE FOR INSECTS. Coop. Econ. Insect Rpt. 9(16): 297-299, illus.
(Plans for cage for use in laboratory or easily transported and quickly erected over a plant or around the stem of a tree to almost any height.)

Squillace, A. E., and Kraus, J. F.
EARLY RESULTS OF A SEED SOURCE STUDY OF SLASH PINE IN GEORGIA AND FLORIDA. Fifth South. Conf. on Forest Tree Improvement Proc. 1959: 21-34.
(Seed collected from an apparently optimum climatic zone seems to be moderately superior even when planted in other climates within the range of the species.)

Storey, T. G., Wendel, G. W., and Altobellis, A. T.
TESTING THE TBM AERIAL TANKER IN THE SOUTHEAST. Southeast. Forest Expt. Sta. Paper 101, 25 pp., illus.
(Pattern sizes and rates of slurry application for half load and full load TBM drops in a variety of fuel types in Georgia and North Carolina.)

Taras, M. A., and Hudson, Monie
SEASONING AND PRESERVATIVE TREATMENT OF HICKORY CROSSTIES. Southeast. Forest Expt. Sta. Hickory Task Force Rpt. 8, 24 pp., illus.
(Compilation of six years work on seasoning and treatability of hickory crossties by various railroads, schools, treating companies, and public agencies.)

Trousdell, K. B.
SITE TREATMENT REDUCES NEED FOR PLANTING AT LOBLOLLY HARVEST TIME. Southeast. Forest Expt. Sta. Paper 102, 11 pp., illus.
(Loblolly pine regenerates naturally provided seed trees are adequate, harvest takes place in moderately good seed year, soil is scarified, and hardwoods are controlled.)

Vimmerstedt, J. P.
SITE INDEX CURVES FOR SOUTHERN APPALACHIAN WHITE PINE PLANTATIONS. Southeast. Forest Expt. Sta. Res. Note 131.
(Regression of logarithm of total height on reciprocal of age was computed and expressed in terms of site index at age 25 years.)

Walker, L. C., and Brender, E. V.
PLANTING FOLLOWING PRESCRIBED FIRE. Jour. Forestry 57: 123-124.
(Planting immediately after a winter burn can be an effective way to convert brush to good pine stocking.)

Whisnant, H. H., and Olson, D. F., Jr.
A PLANTING BAR EXTENSION FOR SETTING LARGE-ROOTED SEEDLINGS. Tree Planters' Notes 36: 6-7, illus.
(How to make and use a sheet metal extension on a standard planting bar when larger holes are needed in hand planting.)

Zak, Bratislav
LITTLELEAF DISEASE OF SHORTLEAF PINE (PINUS ECHINATA MILL.). (Abs.) IX Internatl. Bot. Cong. Proc. 2: 440-441.
(Littleleaf is usually associated with poorly drained soils. It results from a combination of root killing by the soil fungus *Phytophthora cinnamomi*, poor soil aeration, and low soil fertility.)